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SUGARBEET RESEARCH

1966 REPORT

Compiled by Sugarbeet Investigations

**CROPS RESEARCH DIVISION
AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE**

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
Crops Research Division
Beltsville, Maryland

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1966 REPORT^{1/}

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^{1/} This progress report of cooperative investigations contains data, the interpretation of which may be modified with additional experimentation. Therefore, publication, display, or distribution of any data or statements herein should not be made without prior written approval of the Crops Research Division, ARS, U.S. Department of Agriculture, and the Cooperating Agency or agencies concerned.

F O R E W O R D

SUGARBEET RESEARCH is an annual compilation of the research accomplishments by staff members of Sugarbeet Investigations and Cooperators. The data in most of the progress reports are later used in the preparation of comprehensive manuscripts for technical publications.

The reports present results of investigations strengthened by contributions received under Cooperative Agreements between Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, and the Beet Sugar Development Foundation; the Farmers and Manufacturers Beet Sugar Association; and Union Sugar Division, Consolidated Foods Corporation.

At Salinas, California, research is further strengthened through contributions from the California Beet Growers Association, Ltd.

TRADE NAMES occur in these progress reports solely to provide specific information and do not signify endorsement by the U.S. Department of Agriculture.

APPENDIX

RESEARCH RESULTS is an annual compilation of the research accomplishments by staff members of Federal Investigation and Laboratory. The data is made of the progress reports and later sent to the organization of cooperative manuscript for technical publication.

The reports present results of investigations as mentioned by contributions received from Cooperative Agreement between State Research Division, Agricultural Research Service, U.S. Department of Agriculture, and the East Texas Agricultural Foundation, the Farmers and Manufacturers East Texas Association, and West Texas Sugar Division, Consolidated Food Corporation. As follows, California, research is further strengthened through contributions from the California State University Association, Ltd.

THAT NAME occurs in these documents reports solely in provide specific information and do not elicit endorsement by the U.S. Department of Agriculture.

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HIGHLIGHTS OF ACCOMPLISHMENTS

New developments in breeding research comprise 25 items which were made available to cooperators for seed production and utilization (Part I). The items are diverse and each carries one or more desirable characters, such as monogerm seed, excellent quality, cytoplasmic male sterility, tetraploidy, and resistance to certain major pathogens of the sugarbeet. The distribution of seed of the various items to cooperators through the Beet Sugar Development Foundation is given on pages 13-16. Statistics of commercial sugarbeet seed production in the United States continue to indicate almost complete changeover from multigerm to monogerm cultivars (page 17).

Evaluation of new hybrids in California demonstrated that in gross sugar production and sucrose percentage, the monogerm hybrids, US H7 and US H8, are essentially equal to US H6, a multigerm hybrid taken as a standard. US H8 showed slightly better curly top resistance than either US H7 or US H6. In these three-way crosses, all parental lines of US H8 are inbred whereas US H7 has an open-pollinated pollen parent. US H8 has responded more sharply to differences in environmental factors than US H7 as well as suffering more severely under root-rot exposure in the Imperial Valley.

Using diploid monogerm F₁ as seed parents and a multigerm tetraploid line as pollen parent, triploid hybrids were produced that were superior to US H6 in both beet yield and sucrose percentage.

Virus yellows resistance was appraised in new lines of sugarbeet which had been derived from previous selection for tolerance. All plants in certain plots were inoculated with a mixture of beet yellows virus and western beet virus. Companion plots of uninoculated plants remained fairly free of disease symptoms until harvest. In inoculated populations, beet yields were reduced from 18.2 to 40.0 percent and reductions in sucrose ranged from 0.76 to 1.63 percentage points. Several lines which benefited from repetitive generations of selection for resistance suffered less than half the loss in beet yield and sucrose percentage as did US 75 from which they had been derived. Selection 534, developed by the Instituut voor Rationele Suikerproductie, Bergen-op-Zoom, Netherlands, was excellent in beet yield and sucrose percentage. Maris Vanguard, developed at the Plant Breeding Institute, Cambridge, England, was found to be resistant to the viruses but tended to be low in sucrose percentage. These European varieties, which are resistant to virus yellows, could have little direct use in this country because they are susceptible to curly top. However, these sources of virus yellows resistance are

of value in breeding programs. Three-way crosses produced by using virus yellows resistant selections as pollinators demonstrated that the resistance of the pollen parent tends to be imparted to the hybrid offspring. It was reported that ratios of certain amino acid in infected plants could be used as a criterion of virus yellows resistance.

Curly Top: In 1966, curly top was accentuated in areas of the San Joaquin Valley of California by high temperatures and other unfavorable conditions. For some fields, the beet yield was less than 10 tons per acre and in a few fields the crop was a total loss. A survey was made to determine the strains of the virus involved in this unexpected manifestation of the disease. In the early part of the season, the strains of the curly top virus isolated from infected sugarbeets were less virulent than Strain 11, but late in the growing season, the strains were more virulent than Strain 11 and equal to the Las Banos strain which is capable of causing severe damage in our most tolerant commercial varieties.

Curly Top Resistance: Severe epidemics of curly top occur at irregular intervals in the Intermountain region and 1966 was a "curly top year." In most years, the potential damage to the sugarbeet crop is prevented by the use of tolerant varieties but such varieties may in years of intense disease exposure suffer intolerable damage. Such epiphytotic, as in 1966, serves to emphasize the need of higher levels of curly top resistance in commercial varieties of sugarbeet. Research at the Crops Research Laboratory, Logan, Utah, is aimed at enhancement of curly top resistance in basic breeding material. Much of the work is cooperative in nature and serves a large portion of the national breeding program of sugarbeet improvement. In addition to extensive field trials under induced epidemics of curly top, precise evaluation of breeder lines to specific strains of the virus are conducted in the greenhouse. Plants and progenies that are outstanding in resistance are selected for seed production and further utilization in breeding programs conducted by both the sugar companies and federal employees.

Leaf Spot and Curly Top Resistance: Results of extensive evaluation tests of 1966 confirmed the results of 1965 in showing excellent yield of beets and acceptable sucrose percentage for the monogerm hybrid SL (129 X 133) X SP6322-0. This hybrid which is widely used in the Great Lakes region is moderately resistant to leaf spot, curly top, and Aphanomyces type of root rot. Under severe exposure to Cercospora leaf spot at Fort Collins, Colorado, the monogerm hybrid FC (502/2 X 504) X FC901 consistently exceeded SL (129 X 133) X SP6322-0 in yield of beets, gross sugar, and in sucrose percentage.

Leaf Spot and Black Root Resistance: Breeding research at Plant Industry Station, Beltsville, Maryland, continues to bring about improvement in *Cercospora* leaf spot resistance but increments of advancement decreases as high levels of resistance are attained. The inclusion of more susceptible breeding material in the nursery to maintain adequate inoculum has been advantageous. Screening of progenies for black root resistance has shown progress but increase dosages of the inoculum are required to demonstrate differences in tolerance to *Aphanomyces cochlioides*. Breeding methods now in use should provide lines of extreme field resistance to this pathogen. These lines of exceptional black root resistance are made available for evaluation as parents of improved hybrids for regions subject to losses from this disease complex.

Biochemistry of Leaf Spot Resistance: Previous studies have shown that in a nutrient medium, a phenolic compound, 3-hydroxytyramine, a constituent of the sugarbeet leaf, when oxidized is toxic to the leaf spot pathogen, *Cercospora beticola*. The amount of 3-hydroxytyramine in leaves of sugarbeet correlated with inherent resistance to the disease. The concentration of the compound tends to increase during active growth of plants and expansion of leaves. The maximum concentration is reached at a certain stage of maturity of the plants and declines thereafter.

The previous report of a trend for leaf spot susceptible populations of sugarbeet to reach a maximum and begin to decline in amount of 3-hydroxytyramine at an earlier date than do more resistant populations was not confirmed. In the sugarbeet, polyphenoloxidase is considered to be the oxidizing enzyme that renders the 3-hydroxytyramine toxic to the pathogen. The ionic constituents of the sugarbeet are of interest since the divalent ones may act as catalysts for the enzyme. Copper is of particular interest since it appears to be the central atom in the enzyme molecule. The root juice constituents of sodium, potassium, copper, chlorides, and total nitrogen are positively correlated with each other and negatively correlated with sucrose percentage. Leaf material was analyzed for copper, calcium, and magnesium. Polyphenoloxidase and 3-hydroxytyramine content were determined on extract from the same leaves. A highly negative association of 3-hydroxytyramine and the enzyme polyphenoloxidase was demonstrated. Only slight associations are indicated between components of root juice and leaf extract. Correlations between 3-hydroxytyramine and weight of root were small but positive and generally significant while those for sucrose percentage were inconsistent.

Rhizoctonia Resistance: Four cycles of mass selection for resistance to *Rhizoctonia solani* produced multigerm lines FC 701 and FC 702 which are substantially more resistant to the pathogen than their

respective source populations, GW 674 and C 817. Resistance in these lines is rather striking when infection occurs in midseason or later, but both FC 701 and FC 702 are susceptible to infection in the seedling stage of development. Current research demonstrates that the methodology developed for multigerm lines is effective with monogerm breeding material.

Resistance to the Sugarbeet Nematode: Breeding research, aimed at the transfer to the sugarbeet genetic factors conditioning immunity to the cyst nematode, Heterodera schachtii, found in the viny species comprising the Section Patellares of the genus Beta, has shown further promise of success. Attempts to establish resistance to the pathogen through repetitive selection within cultivars of sugarbeet have been less promising. The current report indicates that measurable differences among selections from populations of sugarbeet are largely due to experimental rather than genetical variability. Previous gains were influenced by the use of inoculum composed of a mixture of soilborne pathogens and the resistance attained was not specific for Heterodera schachtii. A significant breakthrough in the research occurred with the development of a method of hatching cysts of the nematode and obtaining large quantities of partially sterilized eelworms for use as inoculum (page 102).

Ploidy and Seed Development: Research was conducted to determine whether viability of seed at different levels of ploidy is under genetic control. The high percent of unfertilized ovules in tetraploids was associated with irregularities in meiosis and with the formation of inviable egg cells whose chromosome number deviated considerably from 2^n . In this study, actual abortion of ovules is almost the same in diploid and tetraploid populations. Thus, the lower fertility of tetraploid populations is due mainly to sterility of gametes and not to abortion of fertilized ovules. Effectiveness of fertilization and grade of ovule abortion are influenced by both male and female parents but greater importance is indicated for the pollinator than for the seed parent.

Breeding Methods: Field tests to compare double cross hybrids with their single cross components indicate for the characters evaluated that the average values for the single cross parents would give a good indication of the performance of the double cross.

Field tests conducted with 3 tetraploid, 10 triploid, and 12 diploid hybrids derived from the same group of diploid inbred lines showed negligible differences in sucrose percentage associated with ploidy. The triploid hybrids had the highest impurity index due to high potassium content. Stands of plants in the diploid hybrids were superior to those in the triploid and tetraploid hybrids and influenced beet yields.

P A R T I

NEW BREEDING MATERIAL

Items Proposed for Seed Increase

and

Utilization and Distribution of Items

PRODUCTION OF MONOGERM SEED IN U.S.A.

NEW DEVELOPMENTS IN BREEDING RESEARCH

Proposals for Seed Production and Utilization May 18, 1966

Breeder seed and inbred lines that have been developed in the breeding research conducted by the staff of Sugarbeet Investigations are proposed for seed production through the Beet Sugar Development Foundation. Seed not needed for planting overwintering plots will be furnished on request to company members of the Foundation for utilization in their breeding programs. Brief descriptions, current designations, and estimates of seed available August 1 are given for the items.

These new productions of breeding research have been developed by the staff of Sugarbeet Investigations in work conducted under Cooperative Agreements with:

California Agricultural Experiment Station
Colorado Agricultural Experiment Station
Michigan Agricultural Experiment Station
Utah Agricultural Experiment Station
Beet Sugar Development Foundation
Farmers & Manufacturers Beet Sugar Association
Union Sugar Division, Consolidated Foods Corp.

Items Proposed for Seed Increase and Utilization

I. U.S. Agricultural Research Station, Salinas, California.

A. Developments in breeding research by J. S. McFarlane, I. O. Skoyen, and B. L. Hammond.

Item 1. C5564 Monogerm 1 pound

A curly top resistant selection from C2563, which is a good type 0. (Item 1 of 1962.) In 1965 tests at Logan, Utah, C5564 was outstanding in curly top resistance. Bolting resistance is similar to that of C2563.

Item 1. (cont.)

Suggested utilization: Use as a breeding line.
C5564 may be increased for possible use as a curly top resistant, monogerm, inbred parent.

Item 2. C5564HO Monogerm 1 pound

A male-sterile monogerm breeder seed obtained from a cross of 563HO and C5564.

Suggested utilization: Use as seed parent in the production of the male-sterile equivalent of C5564.

Item 3. C685T Multigerm 50 grams

Increase of a tetraploid derived from a type O bolting resistant selection from US 75.

Suggested utilization: Use as a pollen parent and for establishment of the male-sterile equivalent. (See Item 4.)

Item 4. C685THO Multigerm 50 grams

Male sterile of tetraploid US 75 crossed with C685T.

Suggested utilization: Use as a tetraploid breeding line.

Item 5.¹ C534 Multigerm 1 pound

Yellows resistant selection originally received from Dr. Henk Rietberg, Director, Instituut voor Rationele Suikerproductie, Bergen op Zoom, Netherlands. The breeder seed was evaluated and increased in California by J. S. McFarlane and associates. Tests in California have shown C534 to have good bolting resistance, and its yellows tolerance is similar to that of C413 from US 75. C534 is not resistant to curly top.

B. Developments in breeding for nematode resistance, by Charles Price:

Item 6. 590-1 Multigerm 1 pound

Selection for resistance to the cyst nematode, Heterodera schachtii. In Salinas tests (1962-1965), which provided severe exposure to the pathogen, 590-1 has yielded significantly better than US 41, the unselected check.

Breeder seed 590-1 is the final proposal for utilization from the breeding research conducted by Charles Price.

1. Item 5A see page 12.

C. Developments in breeding and genetic research by
Helen and V. F. Savitsky:

Item 7. S-5-333 Multigerm 150 grams

Breeder seed S-5-333 is tetraploid, multigerm, and excellent in curly top resistance. It was produced from curly top tolerant plants selected in 1964 at Logan, Utah, in a field test conducted by A. M. Murphy.

Suggested utilization: Use as tetraploid pollinator with diploid male-sterile lines to produce triploid hybrids.

Item 8. S-5-200 Multigerm 150 grams

Breeder seed S-5-200 is tetraploid, multigerm, and excellent in curly top resistance. It was produced from curly top tolerant plants selected in 1964 at Logan, Utah, in a field test conducted by A. M. Murphy.

Suggested utilization: Use as tetraploid pollinator with diploid male-sterile lines to produce triploid hybrids.

Item 9. S-5-800 Multigerm 150 grams

Breeder seed S-5-800 is tetraploid, multigerm, and excellent in curly top resistance. It was produced from curly top tolerant plants selected in 1964 at Logan, in a field test conducted by A. M. Murphy.

Suggested utilization: Use as tetraploid pollinator with diploid male-sterile lines to produce triploid hybrids.

Item 10. S-4-900 Multigerm 150 grams

Breeder seed S-4-900 is a multigerm tetraploid F_3 line derived from hybridization of a tetraploid strain carrying resistance to curly top with a tetraploid strain of excellent sucrose percentage. It combines good curly top resistance and better sucrose percentage than is usually available.

Suggested utilization: Use as tetraploid pollinator with diploid male-sterile lines to produce triploid hybrids.

Item 11. S-4-903 Multigerm 150 grams

Breeder seed S-4-903 is a multigerm tetraploid F₃ line derived from hybridization of a tetraploid strain carrying resistance to curly top with a tetraploid strain of excellent sucrose percentage. It combines good curly top resistance and better sucrose percentage than usually available.

Suggested utilization: Use as tetraploid pollinator with diploid male-sterile lines to produce triploid hybrids.

II. Crops Research Laboratory, Logan, Utah.

Developments in breeding research of J. C. Theurer,
G. K. Ryser, C. H. Smith, and E. H. Ottley:

Item 12. L-53 Multigerm 1 pound

Breeder seed L-53 is an S₃ line derived from (US 35/2 X Ovana) X CT8. It is almost type O. It is equal to US 41 in curly top resistance and has good combining ability. For performances, see Code OV. 3 in Sugarbeet Research, 1965 Report, pp. 148-165.

Suggested utilization: Use as pollinator in experimental hybrids.

Item 13. L-19 Multigerm 3 pounds

Breeder seed L-19 is an S₁ multigerm inbred line having good combining ability for sucrose percentage. It was included as Entry 3611 in 1965 variety trials. See 1965 Sugarbeet Research, pp. 148-165.

Suggested utilization: Use as breeding line to increase sucrose percentages.

III. Sugarbeet Investigations, Fort Collins, Colorado.

Developments in breeding research by J. O. Gaskill:

Item 14. FC 601/2 Monogerm 1 pound

Type O inbred line with high resistance to both leaf spot and curly top, derived from a backcross program in which US 201, the nonrecurring parent,

Item 14. (cont.)

served as the source of leaf spot resistance and various CTR lines served as the recurring parental type. Preliminary agronomic data for FC 601, an S₁ line, indicated acceptable sucrose percentage and combining ability for root yield (Sugarbeet Research, 1965, Report, pp. 192-196). FC 601/2 is a pool of three S₂ sublines of FC 601. It is segregating for R and r; probably also segregating for Mendelian male sterility (aa). C. L. Schneider, A. M. Murphy, and C. W. Bennett participated in curly top evaluation and selection of parental lines of FC 601/2.

Suggested utilization: Increase FC 601/2 and its male-sterile equivalent, FC 601/2-CMS. Also, cross FC 601/2 with FC 502/2-CMS by including a short row of the latter in the planting of FC 601/2.

Item 15. FC 601/2-CMS Monogerm 1 pound

Male-sterile equivalent of FC 601/2.

Suggested utilization: Increase, using FC 601/2 as the pollinator.

IV. Sugarbeet Investigations, East Lansing, Michigan.

Developments in breeding research by G. J. Hogaboam:

Item 16. EL 33 Monogerm 1 pound

A monogerm type O with some resistance to leaf spot and black root. This is an S₃ line and a sister line of 61G1-01 in the S₂ generation (Item 23, 1961 Report). EL 33 is characterized by long, straight roots and has demonstrated some cold resistance.

Suggested utilization: Increase EL 33 and its male-sterile equivalents.

Item 17. EL 33 C1 Monogerm 100 grams

Male-sterile equivalent (E₄) of EL 33. The source of C1 cytoplasm is SL 9460.

Suggested utilization: Use for seed increase with EL 33 and production of experimental hybrids.

- Item 18. EL 33 C2 Monogerm 1 pound

Male-sterile equivalent (E_3) of EL 33. The source of C2 cytoplasm is C361HO.

Suggested utilization: Use for seed increase with EL 33 and production of experimental hybrids.

- Item 19. EL 35 Monogerm 1 pound

A monogerm type O with some resistance to leaf spot and black root. This is an S_3 line and a sister line of 61G4-01 in the S_2 generation (Item 27, 1961 Report). This inbred line tends to have long, straight roots and has demonstrated some cold resistance. It has shown specific combining ability in a 3-way cross with EL 32 (61G2-01, 1961 Report) when 02 clone or SP 5822-0 is used as pollinator.

Suggested utilization: Increase EL 35 and its male-sterile equivalents.

- Item 20. EL 35 C1 Monogerm 1 pound

Male-sterile equivalent (E_5) of EL 35. The source of C1 cytoplasm is SL 9460.

Suggested utilization: Use for seed increase with EL 35 and for the production of experimental hybrids.

- Item 21. EL 35 C2 Monogerm 1 pound

Male-sterile equivalent (E_4) of EL 35. The source of C2 cytoplasm is C361HO.

Suggested utilization: Use for seed increase with EL 35 and for the production of experimental hybrids.

- Item 22. EL 66B15-0 Multigerm 2 pounds

This Breeder seed is the tetraploid of the multigerm clone 02. Seed from 2nd generation (C_2) from colchicine treatment was received from Estacion Experimental de Aula Dei, Zaragoza, Spain. Seed of SP 61B28-01, diploid (Item 21, 1961 Report), was supplied for tetraploidization under PL 480 contract.

Suggested utilization: Use as pollinator in the production of triploid hybrids.

V. Plant Industry Station, Beltsville, Maryland.

Development in breeding research by G. E. Coe.

Item 23. SP 663448-01 Monogerm 1 pound

Male-sterile companion line to SP 663448-0 which is type 0. This male-sterile phase is being made available for utilization, but the type 0 pollinator will be increased and rechecked for trueness to type 0 at Beltsville. The seed production by the overwintering method will provide seed increase of the male-sterile phase as well as the pollen-fertile phase of the line. Leaf spot resistance of SP 663448-0 is excellent and its black root resistance is moderate.

Suggested utilization: Use in the production of experimental hybrids.

Item 24. SP 663465-01 Monogerm 1 pound

Male-sterile companion of SP 663465-0 which is type 0. This male-sterile phase is being made available for utilization, but the pollinator will be increased and rechecked for trueness to type 0 at Beltsville. The seed production by overwintering method will provide seed increase of the male-sterile phase as well as the pollen-fertile phase of the line. Leaf spot resistance of SP 663465-0 is excellent and its black root resistance is moderate.

Suggested utilization: Use in the production of experimental hybrids.

Item 5A.^{1/}C544 Multigerm 5 pounds

Increase of the cross C330 (Item 5, 1963) x C234. C330 is a yellows resistant selection from US 75 and C234 is a yellows resistant selection obtained from the Instituut voor Rationele Suikerproductie, Bergen op Zoom, Netherlands. Tests at Davis and Salinas have shown C544 to have yellows resistance comparable to that of C413. Root yield and sucrose percentage are also similar to those of C413. Curly top resistance is only fair.

1/ For Item 5 see page 7.

BEET SUGAR DEVELOPMENT FOUNDATION

P. O. BOX 538
FORT COLLINS, COLORADO
80521

UTILIZATION OF USDA SEED RELEASES, 1966

Item numbers and seed numbers are identical with those listed in the release memorandum dated May 18, 1966.

I. U. S. Agricultural Research Station, Salinas, California

A. Developments in breeding research by J. S. McFarlane, I. O. Skoyen, and B. L. Hammond.

Item 1. C5564 Monogerm 1 pound

From the available amount, Amalgamated, Holly and Utah-Idaho each want 10 gm now and Spreckels 5 gm; Spreckels wants stecklings from the plots. The balance of the seed will be used for an increase by the West Coast Beet Seed Company; the increase is to be shared by Amalgamated, American Crystal, Great Western, Holly, Spreckels, Union and Utah-Idaho.

Item 2. C5564HO Monogerm 1 pound

Same utilization and distribution as noted for Item 1.

Item 3. C685T Multigerm 50 grams

The amount of seed available will be distributed now among Amalgamated, American Crystal, Great Western, Holly, Spreckels, Union and Utah-Idaho.

Item 4. C685THO Multigerm 50 grams

Same utilization and distribution as noted for Item 3.

Item 5. C534 Multigerm 1 pound

From the available quantity the following is to be distributed now: Amalgamated - 10 gm; Great Western - 20-50 gm; Holly - 15 gm; Utah-Idaho - 15 gm; Spreckels - 5 gm. Spreckels wants stecklings from the plots. The balance of the seed will be used for an increase by the West Coast Beet Seed Company; the increase is to be shared by American Crystal, F & M, Holly, Spreckels and Union.

Item 5A. C544 Multigerm 5 pounds

From the available quantity the following is to be distributed now: Amalgamated - 15 gm; American Crystal - 25 gm; Great

Western - 50 gm; Holly - 15 gm; Spreckels - 15 gm; Union - 15 gm; Utah-Idaho - 15 gm. The balance of the seed will be used by the West Coast Beet Seed Company for an increase to be shared by American Crystal, Holly, Spreckels, Union and Utah-Idaho.

B. Developments in breeding for nematode resistance by Charles Price.

Item 6. 590-1 Multigerm 1 pound

The amount of seed available will be distributed now among Amalgamated, American Crystal, Great Western, Holly, Spreckels, Union and Utah-Idaho.

C. Developments in breeding and genetic research by Helen and V. F. Savitsky.

Item 7. S-5-333 Multigerm 150 grams

The amount of seed available will be distributed now as follows: F & M - 10 gm; the balance will be shared among Amalgamated, American Crystal, Great Western, Holly, Spreckels, Union and Utah-Idaho.

Item 8. S-5-200 Multigerm 150 grams

Same distribution as noted for Item 7.

Item 9. S-5-800 Multigerm 150 grams

Same distribution as noted for Item 7.

Item 10. S-4-900 Multigerm 150 grams

Same distribution as noted for Item 7.

Item 11. S-4-903 Multigerm 150 grams

Same distribution as noted for Item 7.

II. Crops Research Laboratory, Logan, Utah

Developments in breeding research of J. C. Theurer, G. K. Ryser, C. H. Smith, and E. H. Ottley.

Item 12. L-53 Multigerm 1 pound

The amount of seed available will be distributed now among Amalgamated, American Crystal, Great Western, Holly, Spreckels, Union and Utah-Idaho.

Item 13. L-19 Multigerm 3 pounds

Same distribution as noted for Item 12.

III. Sugarbeet Investigations, Fort Collins, Colorado

Developments in breeding research by J. O. Gaskill.

Item 14. FC 601/2 Monogerm 1 pound

From the available quantity the following is to be distributed now: Amalgamated - 15 gm; American Crystal - 10 gm; Great Western - 10 gm; Holly - 15 gm; Spreckels - 10 gm; Utah-Idaho - 15 gm. The balance of the seed will be used by the West Coast Beet Seed Company for an increase to be shared by American Crystal, F & M, Great Western, Holly and Spreckels.

Item 15. FC 601/2-CMS Monogerm 1 pound

Same distribution as noted for Item 14.

IV. Sugarbeet Investigations, East Lansing, Michigan

Developments in breeding research by G. J. Hogaboam.

Item 16. EL 33 Monogerm 1 pound

The amount of seed available will be distributed now as follows: Utah-Idaho - 15 gm; the balance will be shared among American Crystal, Great Western, Holly and Spreckels.

Item 17. EL 33 C1 Monogerm 100 grams

Same utilization and distribution as noted for Item 16.

Item 18. EL 33 C2 Monogerm 1 pound

Same utilization and distribution as noted for Item 16.

Item 19. EL 35 Monogerm 1 pound

Same utilization and distribution as noted for Item 16.

Item 20. EL 35 C1 Monogerm 1 pound

Same utilization and distribution as noted for Item 16.

Item 21. EL 35 C2 Monogerm 1 pound

Same utilization and distribution as noted for Item 16.

Item 22. EL 66B15-O Multigerm 2 pounds

Same utilization and distribution as noted for Item 16.

V. Plant Industry Station, Beltsville, Maryland

Development in breeding research by G. E. Coe.

Item 23. SP 663448-01 Monogerm 1 pound

The amount of seed available will be distributed now as follows: Utah-Idaho - 15 gm; the balance will be shared among American Crystal, F & M, Great Western, Holly and Spreckels.

Item 24. SP 663465-01 Monogerm 1 pound

Same utilization and distribution as noted for Item 23.

SUGARBEET SEED PRODUCTION IN UNITED STATES, 1955-1966^{1/}

Year of production	100-pound bags			Percent monogerm
	Total	Multigerm	Monogerm	
1955	114,187	114,152	35	Trace
1956	88,279	84,991 ⁸⁴²	3,431 ⁷	3.9
1957	94,547	83,812	10,735	11.4
1958	109,832	82,571	27,261	24.8
1959	111,788	83,594	28,194	25.2
1960	124,545	49,869	74,676	60.0
1961	95,541	25,227	70,314	73.6
1962	93,416	10,768	82,648	88.5
1963	94,447	12,487	81,960	86.8
1964	133,614	15,777	117,837	88.2
1965	93,363	671	92,692	99.3
1966	139,020	4,700	134,320	96.6

^{1/} Production records from Agricultural Statistics.

P A R T I I

Progress reports of research conducted at
U.S. Agricultural Research Station, Salinas, California
and
U.S. Southwest Irrigation Field Station, Brawley, California
by the
Staff of Sugarbeet Investigations, ARS-USDA
in cooperation with:

American Crystal Sugar Company
Holly Sugar Corporation
Union Sugar Division, C. F. Company
Spreckels Sugar Company
California Beet Growers Association
Beet Sugar Development Foundation

Research was conducted by:

J. S. McFarlane	B. L. Hammond
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R. T. Lewellen	D. L. Doney
K. D. Beatty	E. D. Whitney
Helen Savitsky	

REPORT ON FOUNDATION PROJECTS 24 AND 29 ^{1/}

Summary of Accomplishments - 1966

COMPARISON OF US H7 AND US H8--The commercial monogerm varieties US H7 and US H8 have been included in variety tests for the past four years. A summary of the performance of these varieties expressed in percent of the performance of US H6 follows:

	<u>No. of tests</u>			<u>Gross sugar</u>			<u>Sucrose percentage</u>		
	<u>C</u>	<u>CV</u>	<u>Imp.</u>	<u>C</u>	<u>CV</u>	<u>Imp.</u>	<u>C</u>	<u>CV</u>	<u>Imp.</u>
US H7	27	12	17	100	106	99	101	97	103
US H8	24	16	21	98	103	100	100	100	103

C = Coastal valleys CV = Central Valley Imp. = Imperial Valley

The performance of US H7 and US H8 compared favorably with that of US H6 in each of the major sugarbeet producing areas of California. US H7 tended to perform better than US H8 in the coastal valleys and in the Central Valley. In the Imperial Valley the performance of the two hybrids has been about equal.

In the coastal valleys US H7 has shown the best bolting resistance whereas in the Central and Imperial Valleys US H8 is the more bolting resistant. US H8 has shown slightly better curly-top resistance than either US H7 or US H6 in field tests at Thatcher, Utah, and in greenhouse tests at Salinas. The seedling vigor of US H7 is equal or superior to that of US H6 and is superior to that of US H8.

Severe root rot occurred in the northern part of the Imperial Valley during June and July of 1966. US H8 was more susceptible than either US H7 or US H6. This susceptibility to rot has not been observed in other areas nor in other seasons in the Imperial Valley.

All three components of US H8 are inbred lines whereas US H7 utilizes an open-pollinated selection as the pollen parent. US H8 has been found to respond more sharply to environmental differences than does US H7.

^{1/} Research conducted by J. S. McFarlane, I. O. Skoyen, B. L. Hammond, and K. D. Beatty.

PERFORMANCE OF MONOGERM HYBRIDS--Monogerm hybrids were tested by the U.S. Department of Agriculture and the sugar companies in the major sugarbeet producing areas of California. A summary of the performance of fifteen hybrids expressed in percent of US H6 follows:

Hybrid	No. of tests			Gross sugar			Sucrose percentage		
	C	CV	Imp.	C	CV	Imp.	C	CV	Imp.
(562HO x 569) x 663	5	4	7	100	109	99	102	105	100
(562HO x 546) x 464	4	2	5	105	109	109	100	106	101
(563HO x 550) x 464	4	4	7	107	117	106	100	103	99
(563HO x 546) x 663	2	2	4	102	113	105	100	103	101
(563HO x 534) x 464	4	3	5	96	117	96	102	105	101
(562HO x 569) x NB7	4	4	7	98	97	97	99	103	101
(562HO x 546) x NB7	3	2	7	95	97	104	98	99	102
(562HO x 569) x 413	4	-	2	124	---	118	105	---	102
(562HO x 546) x 413	4	-	2	126	---	128	105	---	103
(562HO x 569) x 544	4	-	1	121	---	111	104	---	104
(563HO x 550) x 544	4	-	5	123	---	119	101	---	101
(563HO x 550) x 534	4	-	1	135	---	122	107	---	105
(562HO x 569) x 5402	3	-	1	108	---	103	106	---	101
(563HO x 550) x 5402	2	-	2	107	---	109	103	---	101
(563HO x 550) x 5405	2	-	2	96	---	94	103	---	102

C = Coastal valleys CV = Central Valley Imp. = Imperial Valley

In general the monogerm hybrids yielded as well or better than did the standard check, US H6. The sucrose percentage of the monogerm hybrids also tended to be higher than that of US H6. The NB7 inbred was inferior to the open-pollinated lines 663 and 464 as a pollen parent in the 1966 tests.

The hybrid (563HO x 550) x 464 performed very well in all areas. The seed-bearing parent (563HO x 550) is superior to (562HO x 569) in curly-top resistance and has similar bolting resistance. The 1966 results indicate that hybrids utilizing (563HO x 550) as the seed-bearing parent are worthy of additional testing particularly in the Central Valley. The hybrid (562HO x 546) x 464 also performed well in all districts. The new hybrid (563HO x 534) x 464 produced a lower root yield than US H6 in the coastal valleys and the Imperial Valley but was superior to US H6 in the Central Valley. The (563HO x 534) seed-bearing parent combines high curly-top and bolting resistance.

The pollen parents 413, 544, and 534 are yellows-resistant selections. Results with hybrids involving these selections are discussed in Part VIII dealing with virus-yellows investigations.

Triploid hybrids utilizing the tetraploid pollen parent 5402 performed well in 1966 tests. Both root yields and sucrose percentages tended to be superior to those of US H6. 5402 is the increase of a cross between 663 tetra and S203, a tetraploid from Janasz developed by Dr. V. F. Savitsky.

BOLTING RESISTANCE--Bolting-resistance evaluations were made from December plantings at Salinas and from an October planting at Tracy. The yellows-resistant 413 selection from US 75 was equal to the parent variety in bolting resistance at both Salinas and Tracy. The yellows-resistant hybrid (562H0 x 569) x 413 showed fewer bolters at Salinas and Tracy than did US H7. The monogerm inbreds 4806 and 4664 showed outstanding bolting resistance and were equal in resistance to the best multigerm inbreds.

CURLY TOP RESISTANCE--Curly top caused severe damage to late-planted sugarbeets in the west-central San Joaquin Valley in 1966. Damage was accentuated by high temperatures and in some fields by unfavorable soil conditions. A few fields were abandoned and yields of less than ten ton per acre were reported in some fields. Dr. J. E. Duffus checked infected plants and found a range in the virulence of the virus. During the early part of the growing season he found that most plants were infected with strains less virulent than strain 11. During the latter part of the season he isolated strains more virulent than strain 11 and similar in virulence to the Los Banos strain. The Los Banos strain is one of the most virulent strains that has been isolated and is capable of causing severe damage to our present commercial varieties. The experience of the past season demonstrates the need for continued work on curly-top resistance.

Evaluations for curly-top resistance were made in the field at Thatcher, Utah, and in the greenhouse at Salinas. Adverse growing conditions coupled with a heavy leafhopper infestation caused unthrifty growth and severe damage from curly top at Thatcher. Differences between lines were less clear cut and ratings were less accurate than in previous years. Lines with very good resistance could be identified, however. Monogerm inbreds were identified with resistance superior to that of the multigerm NBL inbred.

Segregating S_2 monogerm lines were planted in blocks and selections made under an extreme curly-top exposure. Mr. A. M. Murphy made selections from seven segregating populations and seed will be produced from individual segregates in the greenhouse at Salinas.

Curly-top resistant ratings obtained in the greenhouse agreed well with those obtained in the field. Greenhouse selections were made for resistance from segregating S_1 and S_2 self-fertile populations. Resistance evaluations of single-plant progenies of greenhouse selections made in 1965 showed an improvement over the original segregating material. The results indicate that progress can be made in the greenhouse when selections are made from self-fertile material. Populations that can be handled in the greenhouse are small compared with the field.

POLYPLOIDY--Dr. B. L. Hammond produced additional autotetraploids from both self-sterile and self-fertile breeding lines. During the past year emphasis has been placed on yellows-resistant lines and on lines with high curly-top resistance. Seed increases were made of tetraploids produced in previous years. Triploid hybrids were produced for testing in 1967.

SEED LOTS MADE AVAILABLE THROUGH THE FOUNDATION--A monogerm inbred designated C5564 was made available in 1966. This type O inbred was selected from C2563 for superior curly-top resistance. Field tests at Thatcher, Utah, in 1965 and 1966 showed C5564 to possess outstanding resistance. C5564 is similar to C2563 in bolting resistance.

A male-sterile monogerm designated C5564HO was also made available. This line was obtained from a cross between 563HO and C5564.

A multigerm tetraploid designated C685T and derived from a type O selection from US 75 was made available. The tetraploid male sterile equivalent of C685T was also distributed.

A multigerm yellows-resistant selection designated C534 is being increased by the Foundation. C534 was originally received from Dr. Henk Rietberg, Director, Instituut voor Rationele Suikerproductie, Bergen op Zoom, The Netherlands. California tests have shown C534 to have yellows-resistance similar to the C413 selection from US 75. C534 also has good bolting resistance and produces high root yields coupled with high sucrose percentage. The selection lacks curly-top resistance.

A multigerm line designated C544 was made available for increase by the Foundation. C544 is the increase of a cross between a yellows-resistant selection from US 75 and C534. Tests at Davis and Salinas have shown C544 to have yellows resistance comparable to that of C413 and C534. Root yield and sucrose percentage have been similar to those of C413. Curly-top resistance is only fair.

Percent bolting in sugarbeet inbreds and F₁ hybrids
planted at Salinas, California, December 8¹, 1965.

Entry		Date of Counting	
No.	Description	7/11/66	8/17/66
		<u>Percent</u>	<u>Percent</u>
<u>Inbreds</u>			
4806	mm inbred	0	1
4664-3	mm inbred	0	2
1547	NB5	0	3
F60-512	NB6	2	4
F56-502	NB1	10	16
4664-5	mm inbred	14	18
F65-534HO	MS of 534	14	18
F65-563	mm inbred	13	19
F64-648	mm inbred	16	21
F64-550	mm inbred	15	22
F65-534	mm inbred	10	22
F65-562HO	MS of 562	19	24
F65-563HO	MS of 563	14	26
F64-562HO	MS of 562	19	27
F64-550HO	MS of 550	21	30
3539T	NB7 (tetra)	24	31
F63-546	mm inbred	21	31
F59-502HO	MS of NB1	17	31
F64-562	mm inbred	22	32
F65-562	mm inbred	24	37
F63-563	mm inbred	36	45
0539	NB7	36	47
F64-649	mm inbred	27	48
F64-569	mm inbred	27	49
F63-563HO	MS of 563	41	58
	L.S.D. (5%)		12

BOLTING NURSERY 1965-1966

Tracy, California

McFarlane Material

Planted: 10-1-65

Counted: 6-23-66

Plots 1 row (30") x 25 feet

VARIETY	SOURCE OR DESCRIPTION	AVERAGE 4 REPS. BOLTING %
F57-68	US75	29
F64-30	YRS US75	22
413C	YRS US75	29
463H1	USH2	62
463H2	USH6	38
463H4	USH7	30
463TH4	USH7(3n)	20
4539H4	USH8	17
4539H8	(562HO x 546) x NB7	18
464H8	(562HO x 546) x 464	41
464H11	(563HO x 550) x 464	41
464H14	(463HO x 534) x 464	31
3425H4	(562HO x 569) x 3425	10
5402H4	(562HO x 569) x 5402	66
5405H11	(563HO x 550) x 5405	37
413H4	(562HO x 569) x 413	21
F64-30H4	(562HO x 569) x F64-30	21
F64-30H8	(562HO x 546) x F64-30	25
534H11	(563HO x 550) x 534	45
544H4	(562HO x 569) x 544	41
544H11	(563HO x 550) x 544	40
F63-64	NB C663	32
F62-63T	663 4 n	26
3425	4n 663 x 4 n NB7	7
1547H1	NB1 x NB5	9
F59-509H1	NB1 x NB3	56
F59-512H1	NB5 x NB6	1
F63-546H3	562HO x 546	15
F63-546H4	563HO x 546	6
F64-569H3	562HO x 569	5
F63-549H3	562HO x 549	5
F56-502	NB1	10
F59-502HO	MS of NB1	16
1547	NB5	8
F59-512	NB6	1
0539	NB7	29
F64-562HO	MS of 562	7
F61-562	mm "o" inbred	0
F63-549	mm "o" inbred	5
F64-550	mm "o" inbred	13
5563	mm "o" inbred	6
5563HO	MS of 5563	0

LEAF SPOT RESISTANCE EVALUATION OF SUGARBEET STRAINS
FURNISHED BY DR. J. S. McFARLANE, 1966
Hospital Farm, Fort Collins, Colorado
Experiment 16A

(Conducted by L. W. Lawson and J. O. Gaskill)

Entry No.	Description	Leaf spot ^{a/}		Vigor ^{b/}
		8/22	8/30	8/15
F64-648	mm inbred from US 401	3.3	4.0	5.3
F64-649	" " " " "	3.0	4.0	5.0
5648-3-1	Subline of F64-648	3.3	4.0	5.0
5648-3-11	" " " "	3.7	4.0	4.0
4581C2	S ₂ (984rr x 648-11)	3.0	4.0	5.7
5857C2	S ₂ (1646-7 x 648-11)	3.7	4.3	5.3
5834	S ₂ (563 x 648-11)	4.0	4.7	4.3
5855C2	S ₂ (US 201rr x 648-11)	2.7	4.0	5.7
5847C2	S ₂ (550 x 648-3)	4.0	4.7	4.0
Acc. 2483	SP 5481-0	3.0	4.0	6.0
Acc. 2591	SP 5822-0	2.3	3.0	6.0
Acc. 2269	Syn. Ck.	4.7	5.0	5.0

^{a/} Leaf spot (K. G. Gould): 0 = no leaf spot; 10 = complete defoliation.

^{b/} Foliage vigor (K. G. Gould): Higher number = greater vigor.

Field Plan: Plots 2 rows x 12'; rows 20" apart; 3 plots of each strain. Artificial inoculation and frequent sprinkling were employed to promote the development of leaf spot.

Remarks: Stand was acceptable for the purposes of this test.

VARIETY TEST, BRAWLEY, CALIFORNIA, 1965-66

Location: U. S. Department of Agriculture, Southwestern Irrigation Field Station.1/

Soil type: Holtville silty clay loam.

Previous crops: Sugarbeets, 1962-63; barley, 1963; barley, 1964; barley and cantaloupes, 1964-65.

Fertilizer used: 44 lbs. per acre phosphorus, actual, preplant.
60 lbs. per acre nitrogen, actual, preplant.
140 lbs. per acre nitrogen, actual, sidedressed
December 16, 1965.

Planting date: September 20, 1965.

Thinning date: October 15, 1965.

Harvest dates: Early harvest, May 3-5, 1966.
Late harvest, June 16, 1966.

Irrigations: Early harvest, 6 irrigations plus 3.17 inches rainfall.
Late harvest, 8 irrigations plus 3.17 inches rainfall.

Diseases and insects: Moderately severe infection with mosaic and yellows viruses occurred in the test plot about December, 1965. Curly top infection was light in the 1965-66 test plot. The test plot was sprayed on September 29 with malathion and on October 28 with methyl parathion plus phosdrin for control of cabbage looper and striped cabbage beetle. Granular 10 percent Thimet was applied on the test plot January 13, 1966 for the control of aphids. The late harvest test was retreated with Thimet April 22, 1966 for control of spider mite.

Experimental design: Planted for early harvest, twenty varieties in a 4 x 5 rectangular lattice design, repeated once, in two-row plots, analyzed as a randomized block; and 10 varieties in a 10 x 10 latin square design, single-row plots, analyzed as a latin square. Planted for late harvest, twelve varieties with 10 replications, in a randomized block design, two-row plots. Rows spaced 30 inches apart. Plots 40 feet long.

Sugar analysis: From two ten-beet samples per plot by Holly Sugar Corporation, Brawley, California.

Remarks: Test designed and results analyzed by the United States Agricultural Research Station, Salinas, California.

1/ Plot under supervision of K. D. Beatty stationed at Southwestern Irrigation Field Station, Brawley, California.

VARIETY TEST, BRAWLEY, CALIFORNIA, 1966

(10 replications of each variety)

Planted: September 20, 1965

Harvested: May 3, 1966

Variety	Description	Acre Yield		Sucrose Percent	Harvest Count Number
		Sugar Pounds	Beets Tons		
413H8	(562H0 x 546) x 413	7,870	23.79	16.6	160
534H11	(563H0 x 550) x 534	7,740	22.42	17.3	165
544H11	(563H0 x 550) x 544	7,450	22.01	17.0	169
544H4	(562H0 x 569) x 544	7,040	20.53	17.2	164
413H4	(562H0 x 569) x 413	6,940	21.02	16.5	160
5402H11	(563H0 x 550) x 5402	6,800	20.27	16.8	150
464H8	(562H0 x 546) x 464	6,710	19.93	16.9	169
5402H4	(562H0 x 569) x 5402	6,550	19.81	16.6	164
464H11	(563H0 x 550) x 464	6,470	19.73	16.4	156
463TH4	(562H0 x 569) x 663 Tetra	6,340	19.86	15.9	154
463H2	(MS of NB1 x NB5) x 663	6,330	19.19	16.5	164
4539H8	(562H0 x 546) x NB7	6,320	18.15	17.4	168
437H8	(562H0 x 546) x 437	6,290	18.79	16.8	167
463H12	(563H0 x 546) x 463	6,200	18.34	16.9	163
F64-425H4	(562H0 x 569) x 3425	6,080	18.30	16.6	159
4539H4	(562H0 x 569) x NB7	5,930	17.38	17.1	165
5405H11	(563H0 x 550) x 5405	5,870	17.31	17.0	138
437H4	(562H0 x 569) x 437	5,860	17.77	16.4	162
463H4	(562H0 x 569) x 663	5,680	17.35	16.4	156
564H14	(563H0 x 534) x 564	5,520	16.49	16.7	145
General MEAN of all varieties		6,500	19.42	16.7	Beets
S. E. of MEAN		236	0.717	0.164	per
Significant Difference (19:1)		658	2.0	0.46	100'
Coefficient of Variation (%)		11.49	11.67	3.1	row

Odds 19:1 = 1.972 x $\sqrt{2}$ x Standard Error of MEAN

VARIETY TEST, BRAWLEY, CALIFORNIA, 1966

(10 replications of each variety)

Planted: September 20, 1965

Harvested: June 16, 1966

Variety	Description	Acre Yield		Sucrose Percent	Harvest Count Number
		Sugar Pounds	Beets Tons		
413H8	(562H0 x 546) x 413	10,940	31.63	17.3	172
544H11	(563H0 x 550) x 544	10,650	31.91	16.7	174
413H4	(562H0 x 569) x 413	10,410	30.84	16.9	164
464H8	(562H0 x 546) x 464	9,460	28.25	16.8	172
5402H11	(563H0 x 550) x 5402	9,200	28.14	16.4	158
464H11	(563H0 x 550) x 464	8,940	27.78	16.1	166
463H2	(MS of NBI x NB5) x 663	8,280	25.22	16.4	166
4539H8	(562H0 x 546) x NB7	8,170	24.61	16.6	162
4539H4	(562H0 x 569) x NB7	8,130	24.44	16.6	165
564H14	(563H0 x 534) x 564	8,130	24.27	16.8	152
5405H11	(563H0 x 550) x 5405	7,800	23.59	16.6	140
463H4	(562H0 x 569) x 663	7,700	23.29	16.6	163

General MEAN of all varieties	8,980	27.00	16.7	Beets
S. E. of MEAN	291	0.95	0.187	per
Significant Difference (19:1)	817	2.66	0.52	100'
Coefficient of Variation (%)	10.26	11.09	3.54	row

Odds 19:1 = $1.984 \times \sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	11	13,267,211	101.93	0.93
Between replications	9	2,652,011	31.37	0.78
Remainder (Error)	99	849,069	8.97	0.35
Total	119			

Calculated F value 15.63** 11.36** 2.65**

** Exceeds the 1% point of significance (F=2.43)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1966

(10 x 10 Latin Square)
(single-row plots)

Planted: September 20, 1965
Harvested: May 3, 1966

Variety	Description	Acre Yield		Sucrose Percent	Harvest Count Number
		Sugar Pounds	Beets Tons		
544	Increase (330 x 234)	6,890	20.86	16.6	165
534	Rietberg YRS	6,580	19.13	17.2	152
530	7th YRS US 75	6,560	21.15	15.5	159
513	7th YRS US 75	6,350	20.35	15.7	159
463H2	(MS of NBl x NB5) x 663	6,290	19.49	16.1	153
537A	3rd YRS 663	6,220	20.19	15.5	162
413C	5th YRS US 75	6,140	19.08	16.1	147
533	3rd YRS 663	5,840	19.27	15.2	158
F63-64	BRS 663	5,400	16.86	16.0	150
F57-68	US 75	4,380	13.92	15.8	161

General MEAN of all varieties	6,070	19.03	16.0	Beets
S. E. of MEAN	156	0.51	0.11	per
Significant Difference (19:1)	440	1.42	0.31	100'
Coefficient of Variation (%)	8.14	8.36	2.20	row

Odds 19:1 = $1.994 \times \sqrt{2} \times$ Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	9	5,206,652	46.77	3.51
Between replications	9	1,349,359	18.48	1.86
Between columns	9	2,788,672	31.66	0.65
Remainder (Error)	72	243,967	2.54	0.12

Total 99

Calculated F value 21.34** 18.41** 28.31**

** Exceeds the 1% point of significance (F=2.67)

VARIETY TEST, SALINAS, CALIFORNIA, 1966

Location: Spence Field of the U. S. Agricultural Research Station.

Soil type: Sandy loam.

Fertilizer used: 730 lbs. per acre 10:10:5, preplant.
275 lbs. per acre ammonium sulfate sidedressed
April 19, 1966.
165 lbs. per acre ammonium sulfate sidedressed
June 29, 1966.

Planting dates: Bolting test, planted December 8, 1966.
Yield tests, planted December 23, 1966.

Thinning dates: Bolting test, February 10, 1966.
Yield tests, February 23, 1966.

Harvest dates: Bolting test, September 26, 1966.
Yield tests, September 22-28, 1966.

Irrigation: Sprinkler irrigation as required up to April 25, 1966.
Subsequently, furrow irrigation used at about ten-day
intervals.

Diseases and insects: Symptoms of yellows virus infection were
evident throughout the uninoculated test plots by mid July.
Test plots were sprayed March 24 and April 13, 1966 with
Meta-systox R at a rate of one and one-half pints per acre
for control of green peach aphid.

Experimental design: Bolting test planted in a randomized block
with four replications. Varieties planted in single-row plots;
plots 68 feet long. Yield test of 20 varieties planted in a
randomized block with ten replications. Varieties planted in
two-row plots; plots 53 feet long. Row spacing 28 inches wide.

Sugar analysis: From two samples per plot, of approximately ten
roots each, at the sugar analytical laboratory, United States
Agricultural Research Station, Salinas, California.

VARIETY TEST, SALINAS, CALIFORNIA, 1966

(4 replications of each variety)

Planted: December 8, 1965

Harvested: September 26, 1966

Variety	Description	Acre Yield		Sucrose Percent	Bolting Percent	Harvest Count Number
		Sugar Pounds	Beets Tons			
544H11	(563H0 x 550) x 544	11,500	34.47	16.7	10.9	139
413H4	(562H0 x 569) x 413	11,380	33.07	17.3	6.7	161
534H11	(563H0 x 550) x 534	10,950	31.59	17.4	9.0	148
534	Rietberg YRS	10,740	30.18	17.9	1.9	146
4716H3	562H0 x 4716-18	10,460	31.71	16.5	12.4	146
413C	5th YRS US 75	10,250	29.07	17.6	9.7	156
413H8	(562H0 x 546) x 413	10,180	29.64	17.2	10.7	140
F64-30H8	(562H0 x 546) x F64-30	10,080	29.38	17.2	11.8	144
544	Increase (330 x 234)	10,080	29.74	17.0	7.0	144
544H4	(562H0 x 569) x 544	9,980	29.88	16.8	10.4	144
5402H4	(562H0 x 569) x 5402	9,760	28.39	17.2	10.2	147
F64-30H4	(562H0 x 569) x F64-30	9,650	28.95	16.7	12.4	149
5402H11	(563H0 x 550) x 5402	9,440	28.63	16.6	13.7	135
437H8	(562H0 x 546) x 437	9,270	28.64	16.2	9.2	160
464H11	(563H0 x 550) x 464	9,250	28.89	16.1	11.7	146
464H8	(562H0 x 546) x 464	9,090	28.55	15.9	6.5	158
F64-30	YRS US 75	8,900	26.35	16.9	3.2	148
F64-425H4	(562H0 x 569) x 3425	8,900	27.37	16.3	14.9	149
463TH4	(562H0 x 569) x 663 T	8,890	27.29	16.4	16.0	161
437H4	(562H0 x 569) x 437	8,770	27.94	15.8	15.1	156
463H12	(563H0 x 546) x 463	8,720	27.40	15.9	9.0	150
Lot 5476	(562H0 x 569) x NB7	8,690	27.36	15.9	22.7	144
463H2	(MS of NB1 x NB5) x 663	8,640	26.85	16.1	12.7	163
F63-64H4	(562H0 x 569) x 264	8,510	25.23	16.8	17.3	164
Lot 5536	(562H0 x 569) x NB7	8,440	26.71	15.8	31.3	140
463H4	(562H0 x 569) x 663	8,430	25.58	16.4	13.4	158
5402	Inc. (263T x S203)	8,350	25.10	16.7	6.3	139
F60-512H1	MS of NB5 x NB6	8,350	26.50	15.7	3.0	139
4539H4	(562H0 x 569) x NB7	8,250	25.64	15.9	37.3	159
263TH2	(MS of NB1 x NB5) x 663 T	8,230	25.61	16.0	7.7	131
Lot 5426	(562H0 x 546) x 464	8,210	25.54	16.1	10.1	144
5405H11	(563H0 x 550) x 5405	7,970	23.90	16.6	17.5	114

VARIETY TEST, SALINAS, CALIFORNIA, 1966 continued

(4 replications of each variety)

Planted: December 8, 1965

Harvested: September 26, 1966

Variety	Description	Acre Yield		Sucrose Percent	Bolting Percent	Harvest Count Number
		Sugar	Beets			
		Pounds	Tons			
437B	YRS 663	7,930	25.34	15.6	6.6	156
F64-425H8	(562H0 x 546) x 3425	7,780	23.73	16.4	8.9	142
4539H12	(563H0 x 546) x NB7	7,720	23.76	16.3	39.3	136
4539H11	(563H0 x 550) x NB7	7,700	23.79	16.2	32.8	147
4539H8	(562H0 x 546) x NB7	7,680	24.43	15.8	31.4	141
F64-63T	Tetra 663	7,600	23.82	15.9	2.0	148
F63-64	Bolt. res. 663	7,440	23.00	16.2	7.1	141
F57-68	US 75	7,380	23.90	15.4	7.6	132
F64-546H3	562H0 x 546	7,210	20.69	17.4	15.8	143
F64-550H4	563H0 x 550	6,950	20.87	16.6	23.1	119
1547H1	MS of NBL x NB5	6,900	22.35	15.4	12.0	135
F64-425	663 T x 8539 T	6,890	21.03	16.5	3.2	142
564H14	(563H0 x 534) x 564	6,730	20.95	16.1	9.1	119
663	(US15 x US22/3) sel.	6,380	20.59	15.6	3.0	119
F64-569H3	562H0 x 569	6,070	17.83	17.0	19.9	144
5405	Inc. (S203 x 1401)	5,980	18.63	16.1	9.4	126
General MEAN of all varieties		8,600	26.17	16.4	12.96	Beets
S. E. of MEAN		524	1.72	0.32	1.94	per
Significant Difference (19:1)		1,465	4.81	0.90	5.41	100'
Coefficient of Variation (%)		12.20	13.14	3.92	29.89	row

Odds 19:1 = $1.976 \times \sqrt{2} \times \text{Standard Error of MEAN}$

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S			
		Gross Sugar	Tons Beets	Percent Sucrose	Percent Bolting
Between varieties	47	7,349,618	53.73	1.40	317.35
Between replications	3	36,568,713	325.74	3.75	107.85
Remainder (Error)	141	1,100,036	11.83	0.41	15.01
Total	191				
Calculated F value		6.68**	4.54**	3.38**	21.14**

** Exceeds the 1% point of significance (F=1.66)

VARIETY TEST, SALINAS, CALIFORNIA, 1966

(10 replications of each variety)
(Two-row plots)

Planted: December 23, 1965
Harvested: September 28, 1966

Variety	Description	Acre Yield		Sucrose Percent	Bolting Percent	Harvest Count Number
		Sugar	Beets			
		Pounds	Tons			
534H11	(563HO x 550) x 534	11,470	30.30	19.0	4.0	140
544H11	(563HO x 550) x 544	11,090	30.91	17.9	4.0	140
413H8	(562HO x 546) x 413	10,520	28.76	18.3	2.8	135
544H4	(562HO x 569) x 544	10,390	28.63	18.1	1.9	146
413H4	(562HO x 569) x 413	10,080	27.58	18.3	3.7	141
464H8	(562HO x 546) x 464	9,880	27.53	17.9	3.8	137
5402H4	(562HO x 569) x 5402	9,780	26.67	18.4	3.1	140
463TH4	(562HO x 569) x 663 Tetra	9,600	28.33	17.0	3.0	129
437H4	(562HO x 569) x 437	9,280	25.97	17.9	3.8	141
463H4	(562HO x 569) x 663	9,210	25.70	17.9	2.7	144
5402H11	(563HO x 550) x 5402	9,190	26.60	17.3	2.5	133
464H11	(563HO x 550) x 464	9,190	26.38	17.4	2.2	137
F64-425H4	(562HO x 569) x 3425	9,090	25.50	17.8	2.4	147
463H12	(563HO x 546) x 463	9,060	26.60	17.1	3.9	137
437H8	(562HO x 546) x 437	8,800	25.38	17.3	2.3	140
4539H4	(562HO x 569) x NB7	8,780	25.26	17.4	3.7	141
463H2	(MS of NB1 x NB5) x 663	8,770	25.91	16.9	2.0	141
4539H8	(562HO x 546) x NB7	8,680	24.96	17.4	2.7	138
5405H11	(563HO x 550) x 5405	8,660	25.17	17.3	2.5	110
564H14	(563HO x 534) x 564	8,510	24.44	17.5	2.7	109
General MEAN of all varieties		9,500	26.88	17.7		
S. E. of MEAN		242	0.68	0.21		Beets per
Significant Difference (19:1)		677	1.90	0.59		100'
Coefficient of Variation (%)		8.07	8.00	3.79		row

Odds 19:1 = $1.97 \times \sqrt{2} \times \text{Standard Error of MEAN}$

VARIETY TEST, TRACY, CALIFORNIA, 1966

South Tracy - CTR-NB

By Holly Sugar Corporation

Variety or Lot No.	Description	Acre Yield		Sucrose Percent	Bolters Percent	Harvest Count Number
		Sugar Pounds	Beets Tons			
463H11	(563HO x 550) x 663	9,724	27.34	17.8	2.1	172
464H14	(563HO x 534) x 464	9,374	26.92	17.4	2.5	170
F64-3OH4	(562HO x 569) x F64-30	8,921	25.90	17.2	7.2	167
463H2	US H6	8,428	24.95	16.9	5.8	166
F64-425H4	(562HO x 569) x 3425	8,129	23.15	17.6	4.4	167
263TH4	(562HO x 569) x 663T	7,732	22.58	17.1	1.5	154
L.4126	US H8	7,224	21.63	16.7	6.2	155

General MEAN of all varieties	8,873	25.86	17.2	Beets
S. E. of MEAN	328 ^{A/}	0.88	0.25	per
Significant Difference (19:1)	912	2.45	0.68	100'
Coefficient of Variation (%)	3.70	3.41	1.43	row

A/ Short cut formula

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S	
		Tons Beets	Percent Sucrose
Between varieties	41	37.059	1.433
Between replications	8	63.428	7.695
Remainder (Error)	328	7.009	0.544
Total	377		

Calculated F value 5.29** 2.63**

**Exceeds the 1% point of significance (F=1.64)

Plot Size: 2 rows (30") x 53' planted
2 rows (30") x 50' harvested

Design: 6 x 7 Rectangular lattice - 9 reps (analyzed as random block)
Planted: May 19, 1965
Harvested: March 28, 1966
Harvest: Yield - entire plot; Sucrose - 2 - 25 lb. samples per plot

Remarks: Excellent test - no problems.

The above results were extracted from a test of 42 varieties.

Bolter count was taken on 4 replications.

VARIETY TEST, PIXLEY, CALIFORNIA, 1966

South San Joaquin Early Plant

By Holly Sugar Corporation

Variety or Lot No.	Description	Acre Yield		Sucrose Percent	Purity Percent	Harvest Count Number
		Sugar Pounds	Beets Tons			
464H11	(563H0 x 550) x 464	6,532	30.81	10.6	79.0	168
263TH4	(562H0 x 569) x 663T	6,488	33.79	9.6	79.3	165
464H14	(563H0 x 534) x 464	6,376	28.21	11.3	79.9	176
F64-30H4	(562H0 x 569) x F64-30	6,104	26.31	11.6	79.9	176
F63-64H4	(562H0 x 569) x 264	6,040	26.04	11.6	82.0	177
463H12	(563H0 x 546) x 463	5,588	26.87	10.4	78.5	175
F64-425H4	(562H0 x 569) x 3425	5,484	26.37	10.4	80.0	168
463H8	(562H0 x 546) x 663	5,426	24.67	11.0	80.4	166
L.5517	US H8	5,400	24.33	11.1	81.7	168
463H2	US H6	4,901	23.79	10.3	80.9	164
4539H8	(562H0 x 546) x NB7	4,855	24.52	9.9	78.8	161

General MEAN of

all varieties	5,852	26.26	11.2	80.0	Beets
S. E. of MEAN	379 ^A	1.39	0.42	0.93	per
Significant Difference (19:1)	1,061	3.89	1.17	NS	100'
Coefficient of Variation (%)	6.48	5.30	3.74	1.16	row

^A/ Short cut formula

Odds 19:1 = 1.98 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Tons Beets	Percent Sucrose	Percent Purity
Between varieties	24	41.03374	3.76148	5.190
Between replications	5	240.13630	13.71280	15.751
Remainder (Error)	120	11.60218	1.04518	5.136
Total	149			
Calculated F value		3.54**	3.60**	NS

**Exceeds the 1% point of significance (F=1.94)

Plot Size: 2 rows (30") x 53' planted
2 rows (30") x 50' harvested

Design: 5 x 5 triple lattice (analyzed as 6 rep. R.B.)

Planted: February 17, 1966

Harvested: August 9, 1966

Harvest: Yield - entire plot; Sucrose - 2 - 25 lb. samples per plot

Remarks: Poor test. Three reps lost due to rot. Moderate amount of curly top infection could have reduced yields some.

The above results were extracted from a test of 25 varieties.

VARIETY TEST, MERCED, CALIFORNIA, 1966

South San Joaquin Late Plant

By Holly Sugar Corporation

Variety or Lot No.	Description	Acre Yield		Sucrose Percent	Purity Percent	Harvest Count Number
		Sugar Pounds	Beets Tons			
464H11	(563H0 x 550) x 464	5,526	17.41	15.9	88.6	136
L.3528	US H7	5,188	15.71	16.5	87.4	140
463H2	US H6	5,160	15.88	16.3	88.2	143
L.5517	US H8	4,721	14.36	16.4	87.9	154
General MEAN of all varieties		5,322	16.06	16.6	87.9	Beets
S. E. of MEAN		239 ^{A/}	0.66	0.29	0.69	per
Significant Difference (19:1)		667	1.85	0.81	NS	100'
Coefficient of Variation (%)		4.49	4.14	1.76	0.79	row

^{A/} Short cut formula

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N	S Q U A R E S	
		Tons Beets	Percent Sucrose	Percent Purity
Between varieties	29	9.48135	1.69070	5.931
Between replications	8	38.07519	2.98923	14.909
Remainder (Error)	232	3.97301	0.76158	4.311
Total	269			
Calculated F value		2.39**	2.22**	NS

**Exceeds the 1% point of significance (F=1.79)

Plot Size: 2 rows (30") x 53' planted
2 rows (30") x 50' harvested

Design: 5 x 6 rectangular lattice

Planted: March 17, 1966

Harvested: September 28, 1966

Harvest: Yield - entire plot; Sucrose - 2 - 25 lb. samples per plot

Remarks: Low yield due to lack of irrigation water and severe weed infestation. Low percent infection of curly top throughout plot, but it should have had only a slight effect on the test.

The above results were extracted from a test of 30 varieties.

VARIETY TEST, IMPERIAL VALLEY, CALIFORNIA, 1966

1st Date of Harvest

By Holly Sugar Corporation

Variety or Lot No.	Description	Acre Yield		Sucrose Percent	Purity Percent	Harvest Count Number
		Sugar Pounds	Beets Tons			
4539H8	(562H0 x 546) x NB7	6,063	25.48	11.9	87.2	110
L.3528	US H7	6,007	24.62	12.2	87.3	129
463H11	(563H0 x 550) x 663	5,999	25.21	11.9	87.1	122
L.4664	US H8	5,917	24.86	11.9	86.9	111
463H4	US H7	5,888	24.13	12.2	86.6	132
463H12	(563H0 x 546) x 463	5,804	24.60	11.8	86.6	124
463H2	US H6	5,477	23.40	11.7	87.4	116

General MEAN of all varieties	5,797	23.83	12.2	87.2	Beets
S. E. of MEAN	146 ^{A/}	0.54	0.13	0.56	per
Significant Difference (19:1)	410	1.52	0.37	NS	100'
Coefficient of Variation (%)	2.53	2.28	1.09	0.64	row

^{A/} Short cut formula

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Tons Beets	Percent Sucrose	Percent Purity
Between varieties	15	14.229	0.794	4.480
Between replications	8	11.110	2.927	13.430
Remainder (Error)	120	2.657	0.159	2.772
Total	143			
Calculated F value		5.35**	4.98**	NS

**Exceeds the 1% point of significance (F=2.15)

Plot Size: 2 rows (32") x 53' planted
2 rows (32") x 50' harvested

Design: 4 x 4 triple - 9 reps analyzed as R.B.

Planted: September 20, 1965

Irrigated: September 21, 1965

Harvested: May 23, 1966

Harvest: Yield - entire plot; Sucrose - 2 - 25 lb. samples per plot

Remarks: Poor emerged stand: Beet yellows began to appear in late January. Rot quite prevalent at 2nd date of harvest and progressing to such an extent that 3rd date of harvest not feasible.

Extracted from a test of 16 varieties.

VARIETY TEST, IMPERIAL VALLEY, CALIFORNIA, 1966

2nd Date of Harvest

By Holly Sugar Corporation

Variety or Lot No.	Description	Acre Yield		Purity Percent	Rotten Percent	Harvest Count
		Sugar Pounds	Beets Tons			
L.3528	US H7	5,803	25.91	85.2	4	119
463H4	US H7	5,789	25.61	85.6	5	127
463H11	(563H0 x 550) x 663	5,560	25.51	85.9	7	118
463H12	(563H0 x 546) x 463	5,472	24.65	86.3	5	135
463H2	US H6	5,166	23.48	86.2	7	116
L.4664	US H8	4,744	22.59	84.4	19	123
4539H8	(562H0 x 546) x NB7	4,508	22.32	84.2	29	109
General MEAN of all varieties						
		5,406	24.16	11.2		Beets per 100' row
S. E. of MEAN		195A/	0.74	0.21		
Significant Difference (19:1)		545	2.08	0.59	NS	
Coefficient of Variation (%)		3.60	3.08	1.87		

A/ Short cut formula

Plot Size: 2 rows (32") x 53' planted
2 rows x 50' harvested

Design: 4 x 4 triple lattice - 9 reps analyzed as randomized block
Planted: September 20, 1965
Irrigated: September 21, 1965
Harvested: July 5, 1966
Harvest: Yield - entire plot; Sucrose - 2 - 25 lb. samples per plot

Remarks: Poor emergent stands: Beet yellows began to appear in late January. Rot quite prevalent at 2nd date of harvest and progressing to such an extent that 3rd date of harvest not feasible.

The above results were extracted from a test of 16 varieties.

VARIETY TEST, IMPERIAL VALLEY, CALIFORNIA, 1966

Early plant - Early harvest

By Holly Sugar Corporation

Variety or Lot No.	Description	Acre Yield		Sucrose Percent	Purity Percent	Bolters Percent	Harvest	
		Sugar Pounds	Beets Tons				Count	Number
4539H8	(562H0 x 546) x NB7	6,334	20.47	15.5	87.9	0		145
5444H11	(563H0 x 550) x 544	5,865	20.99	14.0	89.0	0		131
4644H11	(563H0 x 550) x 464	5,485	20.08	13.7	88.5	0		129
463H12	(563H0 x 546) x 463	5,298	19.02	13.9	88.4	0		129
4644H8	(562H0 x 546) x 464	5,104	18.20	14.0	88.8	0.3		130
L.3528	US H7	5,023	18.24	13.8	87.6	0		123
463H4	US H7	4,945	18.24	13.6	87.6	0		132
564H14	(563H0 x 534) x 564	4,895	17.77	13.8	87.3	0.1		121
463H2	US H6	4,848	17.56	13.8	88.3	0		124
L.4664	US H8	4,824	17.18	14.0	87.9	0		130
263TH4	(562H0 x 569) x 663T	4,779	17.58	13.6	87.6	0		126
F64-425H4	(562H0 x 569) x 3425	4,018	16.37	12.3	88.7	0		118

General MEAN of

all varieties	4,703	17.11	13.7	88.1	Beets per 100' row
S. E. of MEAN	1824	0.66	0.04	0.36	
Significant Difference (19:1)	507	1.84	0.12	0.99	
Coefficient of Variation (%)	3.88	3.87	0.32	0.40	

A/ Short cut formula

Plot Size: 2 rows (30") x 53' planted
2 rows (30") x 50' harvested

Design: 6 x 6 triple lattice

Planted: September 11, 1965

Harvested: April 20, 1966

Harvest: Yield - entire plot; Sucrose - 2 - 25 lb. samples per plot

Remarks: No problems - excellent test.

The above results were extracted from a test of 36 varieties.
Bolter count was taken on 6 replications.

Percent Rotted Beets in Two Imperial Valley Tests.

By Holly Sugar Corporation

Variety	Description	Total beets		Rotten beets	
		Test 1	Test 2	Test 1	Test 2
		Number	Number	Percent	Percent
463H4	US H7	1114	1040	31	37
564H14	(563HO x 534) x 464	960	--	35	--
463H2	US H6	1048	867	35	46
464H8	(562HO x 546) x 464	1043	--	35	--
463H12	(563HO x 546) x 463	--	1090	--	39
464H11	(563HO x 550) x 464	1128	927	40	43
544H11	(563HO x 550) x 544	1051	--	43	--
4539H4	US H8	978	758	66	63
4539H8	(562HO x 546) x NB7	976	604	71	90

Both tests planted: 9/20/65

Both tests counted: 7/20/66

Remarks: Beet yellows began to appear in late January. Rot became so severe in July that tests could not be harvested for yield and sucrose.

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1966

TEST AREAS:	S P R E C K E L S #101			S P R E C K E L S #102		
	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar
Variety						
US H7	2.662	25.18	10.5	3.312	29.00	10.8
US H8	2.571	27.34	9.5	2.730	29.10	9.3
463H11				3.137	31.37	10.0
363H8				2.977	29.38	10.1
463H12				2.933	29.00	10.1
564H14				2.705	24.36	11.2
2539H8				2.586	27.35	9.5
4539H12				2.567	26.92	9.5
4539H11				2.289	25.10	9.1
GENERAL MEAN	2.527	25.68	9.9	2.764	27.87	9.9
LSD @ P = .05	0.309	2.41	0.63	0.334	2.76	0.66
LSD @ P = .01	0.409	3.20	0.83	0.444	3.66	0.88
S E of Mean	0.110	0.860	0.224	0.118	0.981	0.235
S E % of Mean	4.35	3.35	2.26	4.27	3.52	2.37
No. Var. in Test		12			12	
Planting Date		12-9-65			12-9-65	
Harvest Date		8-31-66			9-1-66	

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1966

TEST AREAS:	S P R E C K E L S #103			S P R E C K E L S #105		
	Sugar	Beets	%	Sugar	Beets	%
<u>Variety</u>	<u>T/Ac.</u>	<u>T/Ac.</u>	<u>Sugar</u>	<u>T/Ac.</u>	<u>T/Ac.</u>	<u>Sugar</u>
US H7	3.467	30.46	11.5	5.615	37.31	15.1
US H8	3.588	32.41	11.1	5.208	35.06	14.9
363H8	3.639	31.60	11.6			
2539H8	3.451	32.88	10.5			
3539H1	3.503	31.98	11.0	5.300	35.53	14.9
GENERAL MEAN	3.371	30.58	11.0	5.669	37.91	15.0
LSD @ P = .05	0.322	2.64	0.62	0.466	3.40	N.S.
LSD @ P = .01	0.428	3.50	0.82	0.622	5.38	N.S.
S E of Mean	0.115	0.938	0.220	0.164	1.20	0.22
S E % of Mean	3.41	3.07	2.00	2.89	3.16	1.47
No. Var. in Test		12			8	
Planting Date		1-13-66			12-21-65	
Harvest Date		9-2-66			9-14-66	

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1966

TEST AREAS:	G O N Z A L E S #107			K I N G C I T Y #113		
	Sugar	Beets	%	Sugar	Beets	%
<u>Variety</u>	<u>T/Ac.</u>	<u>T/Ac.</u>	<u>Sugar</u>	<u>T/Ac.</u>	<u>T/Ac.</u>	<u>Sugar</u>
US H7	5.704	34.91	16.4	3.331	21.97	15.1
US H8	5.697	34.09	16.7	3.750	25.64	14.6
GENERAL MEAN	5.410	32.55	16.7	3.520	23.72	14.8
LSD @ P = .05	0.782	3.56	0.50	N.S.	N.S.	0.51
LSD @ P = .01	N.S.	4.74	0.67	N.S.	N.S.	0.68
S E of Mean	0.206	1.25	0.177	0.180	1.146	0.181
S E % of Mean	3.81	3.84	1.06	5.11	4.83	1.22
No. Var. in Test		10			8	
Planting Date		1-18-66			2-18-66	
Harvest Date		9-6-66			10-3-66	

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1966

TEST AREAS:	K I N G C I T Y #118			S A N A R D O #119		
	Sugar	Beets	%	Sugar	Beets	%
	<u>T/Ac.</u>	<u>T/Ac.</u>	<u>Sugar</u>	<u>T/Ac.</u>	<u>T/Ac.</u>	<u>Sugar</u>
Variety						
US H7	2.912	31.83	9.2	5.189	35.12	14.8
US H8	3.285	31.38	10.5	4.913	34.63	14.2
GENERAL MEAN	3.046	30.96	9.9	5.055	34.49	14.7
LSD @ P = .05	0.370	2.99	0.87	N.S.	N.S.	0.49
LSD @ P = .01	0.493	3.99	1.16	N.S.	N.S.	N.S.
S E of Mean	0.130	1.052	0.307	0.237	1.722	0.172
S E % of Mean	4.27	3.40	3.10	4.69	4.99	1.17
No. Var. in Test		8			8	
Planting Date		2-18-66			3-4-66	
Harvest Date		10-6-66			10-4-66	

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1966

TEST AREAS:

Variety	W O O D L A N D			D I X O N		
	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar
US H6	3.792	23.62	16.1	5.377	34.55	15.6
US H7	3.851	23.22	16.6			
US H8	3.769	22.82	16.6			
463H8	4.021	24.20	16.7			
364H4				5.944	37.30	15.9
464H14				5.898	36.73	16.1
463H11	4.255	25.70	16.6			
4539H8	3.600	22.08	16.3			
4539H12	3.487	21.12	16.5			
463H12				5.981	37.03	16.2
GENERAL MEAN	3.953	24.06	16.4	5.833	36.47	16.0
LSD @ P = .05	0.623	3.74	0.59	N.S.	N.S.	0.48
LSD @ P = .01	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S E of Mean	0.221	1.33	0.21	0.280	1.77	0.17
S E % of Mean	5.60	5.54	1.28	4.81	4.85	1.06
No. Var. in Test		16			16	
Planting Date		6-2-65			5-7-65	
Harvest Date		5-16-66			4-13-66	

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1966

TEST AREAS:	M E N D O T A #412			B U R R E L L #416		
	Sugar	Beets	%	Sugar	Beets	%
	<u>T/Ac.</u>	<u>T/Ac.</u>	<u>Sugar</u>	<u>T/Ac.</u>	<u>T/Ac.</u>	<u>Sugar</u>
Variety						
US H7				1.509	10.51	14.3
US H8	3.236	25.55	12.7	1.377	9.63	14.3
GENERAL MEAN	2.535	19.66	12.9	1.401	9.80	14.2
LSD @ P = .05	.470	3.65	.604	.258	1.79	N.S.
LSD @ P = .01	.627	4.87	.806	.344	2.38	N.S.
S E of Mean	.166	1.286	.213	.091	.630	.172
S E % of Mean	6.548	6.541	1.651	6.495	6.428	5.733
No. Var. in Test	---			---		
Planting Date	3-17-66			4-4-66		
Harvest Date	10-3-66			9-26-66		

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1966

TEST AREAS:	P A T T E R S O N #404		L I N D S A Y #408		C O A L I N G A #409	
	<u>Sugar T/Ac.</u>	<u>Beets T/Ac.</u>	<u>Sugar T/Ac.</u>	<u>Beets T/Ac.</u>	<u>Sugar T/Ac.</u>	<u>Beets T/Ac.</u>
<u>Variety</u>						
US H7	6.265	40.05	15.7	20.49	12.6	13.9
US H8	5.719	36.57	15.7	16.92	12.1	14.4
GENERAL MEAN	5.964	37.81	15.8	21.04	12.4	13.9
LSD @ P = .05	.438	2.59	N.S.	.418	.5	.5
LSD @ P = .01	.585	3.46	N.S.	.558	.7	.6
S E of Mean	.154	.912	.246	.147	.2	.183
S E % of Mean	3.589	2.411	1.558	5.18	1.6	1.316
No. Var. in Test	8					
Planting Date	1-25-66					
Harvest Date	9-27-66					

VARIETY TEST, EL CENTRO, CALIFORNIA, 1965-66

Grower and location: Kline and Kline, El Centro, California.
Test No. 1.

Soil type: Silty clay loam.

Previous crops: Alfalfa, 1962, 1963 and 1964.

Fertilizer used: 250 lbs. per acre 11:48:0, preplant.
200 lbs. per acre, actual nitrogen, sidedressed
in two applications in November, 1965 and
January, 1966.

Planting date: September 30, 1965.

Thinning date: November 5-6, 1965.

Harvest date: June 9, 1966.

Irrigations: Nine by furrow.

Diseases and insects: Thimet granules applied in January, 1966
for the control of aphids.

Experimental design: Eight varieties planted in a 8 x 8 latin
square. Varieties planted on double-row beds with 40-inch
centers. Plots 60 feet long.

Sugar analysis: From two ten-beet samples per plot by Union Sugar
Division, Imperial Valley Tare Laboratory, El Centro, California.

Remarks: IPC was applied to the field containing the plot in
December, 1965 for control of grass weeds. Seed for the test
plot was furnished, the test designed and the results analyzed
by the United States Agricultural Research Station, Salinas,
California. Plot planted, observed throughout season and
harvested by K. D. Beatty, Southwestern Irrigation Field Station,
Brawley, California, in cooperation with Union Sugar Division.

VARIETY TEST, EL CENTRO, CALIFORNIA, 1966

(8 replications of each variety)

By Union Sugar Division

		Test No. 1			
Variety	Description	Acre Yield		Sucrose Percent	Harvest Count Number
		Sugar	Beets		
		Pounds	Tons		
544H11	(563H0 x 550) x 544	9,030	26.30	17.2	130
464H8	(562H0 x 546) x 464	8,500	24.69	17.2	121
463H2	(MS of NB1 x NB5) x 663	8,300	24.19	17.2	117
464H11	(563H0 x 550) x 464	8,230	24.58	16.8	127
4539H8	(562H0 x 546) x NB7	7,690	22.36	17.2	132
564H14	(563H0 x 534) x 564	7,530	21.89	17.2	97
463H4	(562H0 x 569) x 663	7,400	21.54	17.2	138
4539H4	(562H0 x 569) x NB7	7,280	21.09	17.3	132

General MEAN of all varieties	7,995	23.33	17.2	Beets
S. E. of MEAN	172	0.53	0.12	per
Significant Difference (19:1)	492	1.51	N.S.	100'
Coefficient of Variation (%)	6.09	6.39	2.01	row

Odds 19:1 = $2.021 \times \sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	7	3,037,222	27.69	0.22
Between replications	7	622,875	4.31	1.19
Between columns	7	984,644	10.89	0.60
Remainder (Error)	42	236,918	2.22	0.119
Total	63			
Calculated F value		12.82**	12.47**	N.S.

** Exceeds the 1% point of significance (F=3.10)

VARIETY TEST, EL CENTRO, CALIFORNIA, 1965-66

Grower and location: Kline and Kline, El Centro, California.
Test No. 2.

Soil type: Silty clay loam.

Previous crops: Alfalfa, 1962, 1963 and 1964.

Fertilizer used: 250 lbs. per acre 11:48:0, preplant.
200 lbs. per acre, actual N, sidedressed in two
applications.

Planting date: October 13, 1965.

Thinning date: December 8-9, 1965.

Harvest date: June 14-15, 1966.

Irrigations: Eight by furrow.

Diseases and insects: Of minor importance in the field containing
the test plot.

Experimental design: Eight varieties planted in an 8 x 8 latin
square. Varieties planted on double-row beds with 40-inch
centers. Plots 60 feet long.

Sugar analysis: From two ten-beet samples per plot by Union Sugar
Division, Imperial Valley Tare Laboratory, El Centro, California.

Remarks: Test plot area of field very weedy. Seed for the test plot
was furnished, the test designed and the results analyzed by the
United States Agricultural Research Station, Salinas, California.
Plot planted, observed throughout season and harvested by K. D.
Beatty, Southwestern Irrigation Field Station, Brawley, California,
in cooperation with Union Sugar Division.

VARIETY TEST, EL CENTRO, CALIFORNIA, 1966

(8 replications of each variety)

By Union Sugar Division

Test No. 2

Variety	Description	Acre Yield		Sucrose Percent	Harvest Count Number
		Sugar	Beets		
		Pounds	Tons		
544H11	(563H0 x 550) x 544	7,400	23.68	15.7	147
464H8	(562H0 x 546) x 464	7,260	22.43	16.2	141
4539H8	(562H0 x 546) x NB7	6,640	20.45	16.2	142
464H11	(563H0 x 550) x 464	6,510	21.26	15.4	136
564H14	(563H0 x 534) x 564	6,340	19.58	16.2	122
463H2	(MS of NB1 x NB5) x 663	6,200	19.14	16.2	142
4539H4	(562H0 x 569) x NB7	6,190	19.17	16.1	147
463H4	(562H0 x 569) x 663	6,060	19.12	15.9	146

General MEAN of all varieties	6,574	20.60	16.0	Beets
S. E. of MEAN	183	0.55	0.14	per
Significant Difference (19:1)	524	1.56	0.40	100'
Coefficient of Variation (%)	7.89	7.50	2.47	row

Odds 19:1 = $2.021 \times \sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Gross	Tons	Percent
		Sugar	Beets	Sucrose
Between varieties	7	2,028,775	23.68	0.80
Between replications	7	188,865	1.92	0.25
Between columns	7	406,816	12.43	3.65
Remainder (Error)	42	269,228	2.39	0.156
Total	63			

Calculated F value 7.54** 9.91** 5.15**

** Exceeds the 1% point of significance (F=3.10)

VARIETY TEST, SALINAS, CALIFORNIA, 1966

Grower and location: Elmer Abeloe, Salinas, California.

Soil type: Sandy loam.

Previous crops: Sugarbeets, 1962; beans, 1963; broccoli and lettuce, 1964; beans, 1965.

Fertilizer used: 250 lbs. per acre 21:53:0, preplant.
200 lbs. per acre 27:14:0 sidedressed April 10, 1966.
500 lbs. per acre 20:0:0 (aqua) sidedressed May 10, 1966.

Planting date: February 16, 1966.

Thinning date: April 1, 1966.

Harvest date: October 12-13, 1966.

Irrigations: Seven by furrow.

Diseases and insects: A heavy infection with yellows and mosaic viruses was observed in the field containing the test plot about mid-April, shortly after thinning, indicating infection occurred during the early seedling stage. This resulted in greatly reduced yields in the test. One spray application with Meta-systox was made April 15, 1966 for control of green peach aphid. A moderate nematode infestation was present in the test plot area of the field.

Experimental design: Twelve varieties were planted in a randomized block with 10 replications. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long.

Sugar analysis: From two samples per plot, of approximately ten roots each, by Union Sugar Division, Betteravia, California.

Remarks: Seed for the test plot was furnished, the test designed and the results analyzed by the United States Agricultural Research Station, Salinas, California.

VARIETY TEST, SALINAS, CALIFORNIA, 1966

(10 replications of each variety)

By Union Sugar Division

Variety	Description	Acre Yield		Sucrose Percent	Harvest Count Number
		Sugar	Beets		
		Pounds	Tons		
534H11	(563H0 x 550) x 534	8,910	30.49	14.6	144
413H8	(562H0 x 546) x 413	8,350	29.20	14.3	147
544H11	(563H0 x 550) x 544	8,120	28.28	14.4	143
413H4	(562H0 x 569) x 413	7,900	27.15	14.6	147
544H4	(562H0 x 569) x 544	7,620	25.90	14.8	153
464H11	(563H0 x 550) x 464	7,320	25.06	14.6	138
437H8	(562H0 x 546) x 437	7,190	24.90	14.4	143
564H14	(563H0 x 534) x 564	6,900	23.01	15.0	136
463H8	(562H0 x 546) x 663	6,520	22.41	14.6	141
463H2	(MS of NBL x NB5) x 663	6,480	21.76	14.9	138
4539H4	(562H0 x 569) x NB7	6,410	22.57	14.2	149
463H4	(562H0 x 569) x 663	6,030	20.60	14.7	144

General MEAN of all varieties	7,310	25.11	14.6	Beets
S. E. of MEAN	191	0.54	0.16	per
Significant Difference (19:1)	537	1.52	0.45	100'
Coefficient of Variation (%)	8.27	6.80	3.42	row

Odds 19:1 = $1.984 \times \sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	11	7,909,947	100.27	0.52
Between replications	9	5,326,296	93.65	0.98
Remainder (Error)	99	365,983	2.92	0.25

Total 119

Calculated F value 21.61** 34.34** 2.08*

* Exceeds the 5% point of significance (F=1.88)

** Exceeds the 1% point of significance (F=2.43)

VARIETY TEST, SAN ARDO, CALIFORNIA, 1966

Grower and location: Taylor and Diggs, San Ardo, California.

Soil type: Sandy loam.

Previous crops: Sugarbeets, 1963; beans, 1964; carrots, 1965.

Fertilizer used: 400 lbs. per acre 16:20:0, preplant.
150 lbs. per acre NH_3 , split into two sidedress applications.

Planting date: January 26, 1966.

Thinning date: March 10, 1966.

Harvest date: October 18-19, 1966.

Irrigations: Eight by furrow.

Diseases and insects: Not a factor in the field containing the test plot.

Experimental design: Ten varieties planted in a 10 x 10 latin square. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long.

Sugar analysis: From two samples per plot, of approximately ten roots each, by Union Sugar Division, Betteravia, California.

Remarks: Seed for the test was furnished, the test designed and the results analyzed by the United States Agricultural Research Station, Salinas, California.

VARIETY TEST, SAN ARDO, CALIFORNIA, 1966

(10 x 10 Latin Square)

By Union Sugar Division

Variety	Description	Acre Yield		Sucrose Percent	Harvest Count Number
		Sugar	Beets		
		Pounds	Tons		
544H11	(563H0 x 550) x 544	15,390	48.35	15.9	122
F64-425H4	(562H0 x 569) x 3425	14,720	45.61	16.1	125
564H14	(563H0 x 534) x 564	14,560	43.45	16.7	132
464H11	(563H0 x 550) x 464	14,450	45.41	15.9	125
463H2	(MS of NB1 x NB5) x 663	14,180	43.50	16.3	128
4539H4	(562H0 x 569) x NB7	14,100	44.29	15.9	134
463H8	(562H0 x 546) x 663	14,090	44.15	16.0	125
463H4	(562H0 x 569) x 663	14,020	42.09	16.6	136
5402H4	(562H0 x 569) x 5402	13,890	41.78	16.6	122
4539H8	(562H0 x 546) x NB7	13,880	45.62	15.2	126

General MEAN of all varieties	14,330	44.42	16.1	Beets
S. E. of MEAN	265	0.68	0.15	per
Significant Difference (19:1)	748	1.92	0.44	100'
Coefficient of Variation (%)	5.85	4.85	3.03	row

Odds 19:1 = $1.994 \times \sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	9	2,176,437	37.25	2.09
Between replications	9	11,247,901	36.83	6.03
Between columns	9	5,481,563	18.34	2.09
Remainder (Error)	72	703,300	4.64	0.24
Total	99			
Calculated F value		3.09**	8.03**	8.74**

** Exceeds the 1% point of significance (F=2.67)

DEVELOPMENT OF TRIPLOID AND TETRAPLOID SUGARBEETS

B. L. Hammond

Seed increases of the following tetraploid selections were made at Salinas in 1966 from stecklings grown in Oregon: 585T(F57-85T); 585HOT; 5563T(1561-16-7C1T); 5509T(F59-509R-T); 4562T; 4562HOT; 1515T(F61-515T); 552T; 1547T; 330R-T; 164R-T; F58-554rrT; and 586rrT.

Seed increases of the following new tetraploid selections are being made: 613T, 6704T, 6716T; 6753T; 6757Trr; 6757TR-; 6534T; 6764Trr; 6764TR-; 6546-36T; 6152T(871 x 8539)T; 6153T(F62-63rr x 586R-)T; and 6154T(271rr x 586R-)T. Seed increases are also being made of 686Trr, 686TR-, 664T, 6515T, 630T, and 6559-1T. Seed for these increases was planted in Oregon in August 1966 to produce stecklings for isolation at Salinas in March 1967.

Germinating seed of 234, a self-sterile, yellows-resistant selection obtained from Dr. Rietberg was colchicine-treated and planted in November 1964. Sixty-five promising chimeras were selected for thermal induction in August 1965. Plants were removed from the coldroom in June 1966 and interpollinated. This selection has both green and red hypocotyls.

Pregerminated seed of the monogerm inbred 4806 from F57-85 was colchicine-treated and planted in May 1965. One-hundred fifty-five seedlings were transplanted to pots in June 1965. Sixty-eight good chimeras were placed under thermal induction in September 1965. Plants were removed in March 1966 and interpollinated. This selection has green hypocotyls.

One-hundred fifty colchicine-treated seedlings of selection 4742 were transplanted to pots in August 1965. Seventy plants were selected for thermal induction in October. Plants were removed in May 1966 and interpollinated. This multigerm inbred has red hypocotyls and is yellows resistant.

In June 1965, pregerminated seed of selection F60-512 was colchicine-treated. One-hundred fifty seedlings were potted in September. Seventy plants were placed under thermal induction in January 1966 and removed in September for interpollinating in September. This is a bolting-resistant, multigerm inbred.

Germinating seed of 4754, a yellows-resistant, multigerm inbred-selection, was colchicine-treated in August 1965 and transplanted to pots in November. These were placed in the coldroom for thermal induction in February 1966 and removed in August for selfing.

In January 1966, pregerminated seed of selection 3646-32-5 was colchicine-treated. One-hundred fifty seedlings were potted in April, of which 66 of the best chimeras were placed under thermal induction in September 1966.

Germinating seed of 537A, a self-sterile multigerm, was colchicine-treated in April 1966. One-hundred fifty of these were potted in June, of which 61 (53 with red hypocotyls and 8 with green) were placed in the coldroom in September for thermal induction.

One-hundred fifty colchicine-treated seedlings of selection 5754H4 were transplanted to pots in August 1966. One-hundred of these were selected for thermal induction in November. This male-sterile selection, a yellows-resistant multigerm, will be crossed with type 0 tetraploids to produce male-sterile tetraploid lines.

Germinating seed of the male-sterile selection, 5760H4, were colchicine-treated and planted in May 1966. Ninety-six of these, based on cytological examinations, were selected for thermal induction in November. This male-sterile selection will also be crossed with type 0 tetraploids to produce male-sterile tetraploid lines.

In June 1966, germinated seedlings of 544 were colchicine-treated. Seventy-five each of green and red hypocotyls were potted in November. This is a yellows-resistant, self-sterile multigerm obtained from Dr. Rietberg.

Seedlings of selection 4522, a self-fertile, monogerm inbred, were colchicine-treated and planted in August 1962. One-hundred fifty selected plants were potted in November.

Germinating seedlings of 5703 were colchicine-treated and planted in September 1966. This is a self-fertile, multigerm inbred. One-hundred fifty selected plants were potted in November.

In September 1966, germinating seedlings of 5633 were colchicine-treated and planted. This is a self-fertile, monogerm inbred selection. One-hundred fifty selected plants were potted in November.

In October 1966, seed of the curly-top resistant monogerm inbred, 5601-5-3 was planted for colchicine treatment. This seed did not germinate.

Seedlings of 5605-1-7, a curly-top resistant monogerm inbred selection, was colchicine-treated in November 1966.

Colchicine-treated seedlings of 6705 were planted in November 1966. This is a yellows-resistant, monogerm inbred. It is close to type 0 and will be used in crosses with the male-sterile selection, 6705H24.

Germinating seed of 6705H24 was colchicine-treated in November 1966. This is a yellows-resistant, male-sterile equivalent of 6705 described above and will be used to produce a male-sterile tetraploid line.

A 31-pound seed increase of C6600 was made in Oregon in the summer of 1966. This is a homozygous diploid sugarbeet developed at Salinas and described in earlier reports.

Progress in Breeding for Yellows Resistance

J. S. McFarlane, I. O. Skoyen, and Robert Lewellen

Breeding for yellows resistance continued to be a major project at the U. S. Agricultural Research Station in 1966. Lines with improved resistance were selected from three dates of planting at Salinas. Selections made in previous years were evaluated for resistance at Davis, California. Hybrids produced with yellows-resistant pollinators were evaluated in several variety tests.

Plans and Procedures

Selections for yellows resistance were made at Salinas from beets planted March 4, April 18, and June 17. The March planting included both open-pollinated and inbred lines selected for yellows resistance in previous years. The April planting included segregating male-sterile lines from crosses between monogerm male steriles and inbred yellows-resistant selections. Inbred lines from crosses between yellows-resistant selections were also planted. The June 17 planting included one-third acre of the sixth successive yellows-resistant selection from US 75 made in 1965. Also included was one-half acre of the increase of a cross between a yellows-resistant selection from US 75 and a selection from the Netherlands.

Three evaluation tests were planted at Davis, California, on May 10, 1966. The first test included five open-pollinated, yellows-resistant selections made at Salinas and the parental lines from which the selections had been made. A yellows-resistant variety from England, a selection from the Netherlands, and a cross between a US 75 selection and the Netherlands selection were also included.

A second test was designed to test eleven hybrids involving both open-pollinated and self-fertile, yellows-resistant selections. In each hybrid, the seed-bearing parent was a male-sterile monogerm which had not been selected for yellows resistance.

The third test included eight inbred lines selected for yellows resistance and two yellows-susceptible inbreds.

A modified split-plot design was used for all tests. The treatments, consisting of a noninoculated check and a combination beet and western-yellows inoculation, were arranged in randomized strips across each of five replications. The variety subplots were two rows wide and 43 feet long. In the first test the parental groups were randomized within the replications, and the selections or varieties randomized within the parental groups. The entries in the second and third tests were arranged at random. Stand counts were made following thinning and plant populations adjusted so that a similar number of plants occurred in the inoculated and noninoculated plots of any given entry in each replication. Inoculations were made July 5 with a virulent (Brawley) strain of beet-yellows virus and a virulent strain of western-yellows virus. The tests were harvested October 11-13.

A variety test to determine the performance of yellows-resistant selections and hybrids was planted at Salinas, December 23, 1965. Seventeen selections and hybrids were planted in single-row plots 53 feet long and replicated ten times. Six replications were inoculated with virulent strains of beet and western yellows viruses on April 12 and four replications on April 27. The test was harvested September 22.

Hybrids utilizing yellows-resistant selections as pollen parents were tested in the Salinas Valley and the Imperial Valley.

Results and Discussion

Selection for resistance

Selections made from three plantings at Salinas were based on freedom from yellowing, root size, and sucrose percentage. Emphasis was placed on improving the resistance of 544, an F_2 open-pollinated line from a cross between a US 75 selection and a selection from the Netherlands. This line produced large roots when inoculated with beet and western yellows viruses. Considerable variation occurred in root size and in sucrose percentage. Selections from 544 will bring together resistance from two sources and should provide an opportunity to develop a higher level of resistance than exists in either individual source.

The monogerm inbred 5705 showed good promise. This inbred resulted from a cross between a Type O yellows-resistant, open-pollinated selection and a self-fertile monogerm line. 5705 showed less yellowing than other monogerm inbreds and produced large roots when inoculated with the combination of viruses. Variation existed in root size and sucrose percentage and another selection was made for yellows resistance. An increase was made of 5705 and F_1 hybrids produced with cytoplasmic male steriles. Experimental three-way hybrids between these F_1 hybrids and yellows-resistant pollinators will be produced in 1967.

Davis tests

Good stands were obtained in nearly all entries in the Davis tests and all inoculated plots showed a high level of virus infection. The non-inoculated plots showed very little virus infection until late in the season. Mosaic and yellows symptoms were evident in a high percentage of the noninoculated plants at harvest time. This late infection had little effect on yield and probably did not greatly affect the sucrose of the noninoculated plots.

The combination of beet and western yellows caused root-yield losses ranging from 18.2 to 40.0 percent and sucrose losses ranging from 0.76 to 1.63 percentage points among open-pollinated varieties and selections (table 1). The selection 513 showed less than one-half as great a loss in both root yield and sucrose percentage as did the US 75 variety from which it had been selected. The selection 530 from

Table 1. Reduction in yield and sucrose percentage of yellows-resistant selections and of unselected lines when inoculated with a combination of beet and western yellows viruses at Davis, California, in 1966.

No.	Description	Tons Roots per Acre		Sucrose Percentage		Loss from Yellows	
		Check	Inoculated	Check	Inoculated	Root Yield Percent	Sucrose Pct. Pts.
513	7th YRS US 75	28.8	23.5	13.7	12.9	18.2	0.76
530	7th YRS US 75	32.6	22.8	13.5	12.4	30.1	1.13
F57-68	US 75	27.5	16.6	14.0	12.5	40.0	1.55
537A	3rd YRS 663	32.1	20.6	13.5	11.8	35.8	1.63
F57-63	Increase 663	28.7	18.8	14.1	12.7	34.3	1.44
538A	3rd YRS F57-85	26.6	19.6	14.2	13.0	26.0	1.17
F57-85	Type 0 US 75	19.5	12.4	14.6	13.6	36.4	0.99
521	5th YRS 671	27.0	19.7	13.9	12.3	26.8	1.60
671	Type 0 line	25.7	16.0	14.6	13.0	37.7	1.60
534	YRS from Rietberg	29.5	24.7	14.6	13.8	16.3	0.87
544	Increase (330 x 234)	30.8	24.0	14.0	12.9	22.1	1.07
Acc.119	Maris Vanguard	32.6	24.0	13.0	11.4	25.7	1.57
LSD (5%)		2.04	1.85	0.69	0.63	7.14	NS

US 75 yielded better than did 513 but showed higher yield and sucrose losses from yellows. Selections from 671 and F57-85 showed significant improvements in yellows resistance. No improvement was demonstrated in the third successive selection from F57-63. The selection 534 developed by the Instituut voor Rationele Suikerproductie in the Netherlands produced a high root yield and was outstanding in sucrose percentage. The yellows resistance of 534 was similar to that of 513. Maris Vanguard, a yellows-resistant selection developed by Dr. G. E. Russell of the Cambridge Plant Breeding Institute in England, yielded very well when infected with yellows, but was low in sucrose percentage. The 544 line yielded well and showed good resistance to yellows.

Root-yield losses from yellows among six three-way hybrids produced with yellows-resistant pollinators ranged from 23.0 to 30.5 percent (table 2). The three-way hybrid 463H4 lost 36.2 percent in root yield. This is the US H7 monogerm hybrid and none of the parents was selected for yellows resistance. Root-yield losses among four single-cross hybrids produced with yellows-resistant inbred pollinators ranged from 20.5 to 29.4 percent.

Root-yield losses ranged from 15.0 to 42.2 percent and sucrose losses from 0.70 to 1.88 percentage points among inbred lines selected for yellows resistance (table 3). The susceptible inbred F56-511 showed a yield loss of 48.7 percent and a sucrose loss of 2.11 percentage points. The most promising inbred was 5760, a selection from a cross between a US 75 selection and a self-fertile inbred. This inbred remained green following inoculation and showed a yield loss of 18.8 percent.

Salinas tests

Results with seventeen entries in a Salinas test inoculated with the combination of beet and western yellows viruses are shown in table 4. Selection 534 from the Netherlands yielded well and was outstanding in sucrose percentage. The root yield of the 513 selection was 60 percent higher and the sucrose content 0.9 percentage points higher than those of the parent US 75 variety. Selections from 663 were inferior to the US 75 selections and showed no significant improvement over the parent variety, F63-64. Hybrids with the yellows-resistant 534, 544, 413, and 513 selections, produced higher yields than did hybrids with the unselected 663 pollinator.

The sucrose percentage of seven hybrids in the test inoculated with yellows averaged 15.6 percent, whereas, the same hybrids in an adjacent noninoculated test averaged 18.1 percent (table 5). Cultural practices, planting dates, and harvest dates were similar for the two tests. Both tests ran low on nitrogen during the latter part of the growing season. Two sprays with an aphicide were applied to both tests. These sprays delayed infection in the noninoculated test, but nearly all plants were showing yellows symptoms by September.

Table 2. Reduction in yield and sucrose percentage of sugarbeet hybrids when inoculated with a combination of beet and western yellows viruses at Davis, California, in 1966.

No.	Description	Tons Roots per Acre		Sucrose Percentage		Loss from Yellows	
		Check	Inoculated	Check	Inoculated	Root Yield Percent	Sucrose Pct. Pts.
413H4	(562H0 x 569) x 13	32.5	24.7	15.2	13.6	24.0	1.59
413H8	(562H0 x 546) x 13	32.1	24.7	14.8	13.8	23.0	0.97
4716H3	562H0 x 716	32.2	24.2	14.6	13.3	24.8	1.32
5760H4	563H0 x 760	30.0	23.7	15.1	13.9	20.5	1.22
544H11	(563H0 x 550) x 44	30.7	23.6	14.7	13.5	23.1	1.25
544H4	(562H0 x 569) x 44	31.0	23.4	15.1	13.9	24.7	1.16
F64-30H4	(562H0 x 569) x 30	30.0	21.9	15.2	13.6	27.0	1.62
437H4	(562H0 x 569) x 37	29.8	20.7	14.9	13.4	30.5	1.49
5753H4	563H0 x 753	26.9	19.5	14.3	13.3	27.2	1.15
463H4	(562H0 x 569) x 663	29.5	18.8	15.1	13.3	36.2	1.79
5754H4	563H0 x 754	25.9	18.2	14.3	12.9	29.4	1.46
F61-569H3	562H0 x 569	15.7	10.6	16.6	15.3	30.4	1.35
LSD (5%)		2.60	1.85	0.56	0.58	7.63	NS

Table 3. Reduction in yield and sucrose percentage of sugarbeet inbreds when inoculated with a combination of beet and western yellows viruses at Davis, California, in 1966.

No.	Description	Tons Roots per Acre		Sucrose Percentage		Loss from Yellows	
		Check	Inoculated	Check	Inoculated	Root Yield	Sucrose Pct. Pts.
4734A	YRS (927-35 x 5577-2)	30.9	23.8	13.6	12.9	23.5	0.70
5760	YRS (911 x 9717-4)	19.6	16.0	14.6	13.7	18.8	0.92
4716-18B	YRS (US 56 x NB1)	23.4	15.6	13.7	12.9	34.0	1.05
4757A	YRS (911 x 9716-4)	22.1	15.1	13.2	11.9	32.2	1.30
5768	YRS (926-36 x 9716-8)	22.3	14.9	14.8	13.3	33.1	1.53
4742	YRS (928-9 x 5502)	16.0	13.6	15.1	14.5	15.0	0.73
5753A	YRS (671 x 9716-4)	17.3	12.1	13.5	11.7	30.7	1.81
5754A	YRS (671-22 x 9716-10)	20.4	12.0	13.8	12.0	42.2	1.88
F56-511	NB2	19.6	10.1	14.1	11.9	48.7	2.11
4522	S ₁ (8546-7 x 8561-16)	13.9	7.5	14.3	12.4	44.8	1.88
LSD (5%)		1.70	1.91	0.79	0.90	9.10	0.95

Table 4. Performance of sugarbeet selections and hybrids when inoculated with beet yellows and beet western yellows viruses at Salinas, California, in 1966.

Selection or hybrid	Description	Acre Yield		Sucrose Percent
		Sugar Pounds	Beets Tons	
534	Rietberg YRS	9,080	26.1	17.4
534H11	(563HO x 550) x 534	8,860	27.2	16.4
413H8	(562HO x 546) x 413	8,530	26.3	16.3
513	7th YRS US 75	8,420	26.0	16.2
544	Increase (330 x 234)	8,290	25.2	16.5
544H4	(562HO x 569) x 544	8,060	25.3	16.0
413	5th YRS US 75	8,010	24.4	16.5
413H4	(562HO x 569) x 413	7,770	24.7	15.8
530	7th YRS US 75	7,690	25.4	15.2
463H4	(562HO x 569) x 663	6,450	21.6	15.0
537A	3rd YRS 663	6,360	22.0	14.5
437H4	(562HO x 569) x 437	6,310	21.4	14.8
463H2	(MS of NB1 x NB5) x 663	6,180	20.6	15.0
533	3rd YRS 663	5,910	21.8	13.6
F63-64	BRS 663	5,610	18.9	14.9
CS-42	Commercial variety	4,790	15.9	15.1
F57-68	US 75	4,650	16.3	14.3
	L.S.D. (5%)	644	2.1	0.6

Table 5. Comparison of the performance of yellows inoculated and noninoculated sugarbeet hybrids at Salinas, California, in 1966.

Hybrid	Acre Yield		Sucrose	
	Noninoc. Tons	Inoc. Tons	Noninoc. Percent	Inoc. Percent
534H11	30.3	27.2	19.0	16.4
413H8	28.8	26.3	18.3	16.3
544H4	28.6	25.3	18.1	16.0
413H4	27.6	24.7	18.3	15.8
437H4	26.0	21.4	17.9	14.8
463H4	25.7	21.6	17.9	15.0
463H2	25.9	20.6	16.9	15.0
Ave.	27.6	23.9	18.1	15.6
LSD (5%)	1.9	2.1	0.6	0.6

Root-yield losses from yellows tend to be fairly consistent, but losses in sucrose percentage vary greatly from one test to another. Sucrose losses were greater in the 1966 Salinas test than in any previous test at Salinas or Davis. Additional work will be required to determine the effect of time of infection, soil fertility, and other factors on sucrose losses.

Statewide tests

The performance of hybrids with yellows-resistant pollinators are summarized in tables 6, 7, and 8. Hybrids with 413, the fifth successive selection from US 75, showed good promise. Gross sugar yields of the 413 hybrids were 9 to 42 percent higher than those of US H7 (table 7). The sucrose percentage also tended to be higher in the 413 hybrids (table 8). Tests at Salinas and Thatcher, Utah in 1965 and 1966 showed the two 413 hybrids to be equal or superior to US H7 in bolting and curly-top resistance.

A stock seed increase has been made of 413 and commercial seed of hybrids 413H4 and 413H8 are being produced for harvest in 1967.

The hybrids with 534, a yellows-resistant selection from the Netherlands, not only produced high root yields but were outstanding in sucrose percentage (tables 7 and 8). The 534 hybrids lack curly-top resistance and could be used in very few areas in California.

Hybrids with 544, a cross between a US 75 selection and 534, showed similar performance to the 413 hybrids. The curly-top resistance of 544 is intermediate between 413 and 534. A 0.4 acre seed increase of 544 is being produced for harvest in 1967.

The 437 hybrids which utilized a yellows-resistant selection from 663 as the pollen parent yielded better than US H7, but tended to be inferior in sucrose percentage.

Table 6. Comparison of the performance of hybrids produced with a yellows-resistant pollinator and two commercial varieties in six 1966 variety tests.

Location	Variety	Acre Yield		Sucrose Percent
		Sugar Pounds	Beets Tons	
Brawley (Early harvest)	413H4	6940	21.0	16.5
	413H8	7870	23.8	16.6
	US H7	5680	17.4	16.4
	US H7A	6710	19.9	16.9
	L.S.D. (5%)	658	2.0	0.5
Brawley (Late harvest)	413H4	10,410	30.8	16.9
	413H8	10,940	31.6	17.3
	US H7	7700	23.3	16.6
	US H7A	9460	28.3	16.8
	L.S.D. (5%)	817	2.7	0.5
Salinas (Inoculated)	413H4	7770	24.7	15.8
	413H8	8530	26.3	16.3
	US H7	6450	21.6	15.0
	L.S.D. (5%)	644	2.1	0.6
Salinas (Sprayed)	413H4	10,080	27.6	18.3
	413H8	10,520	28.8	18.3
	US H7	9210	25.7	17.9
	US H7A	9880	27.5	17.9
	L.S.D. (5%)	677	1.9	0.6
Salinas (Severe yellows)	413H4	7900	27.2	14.6
	413H8	8350	29.2	14.3
	US H7	6030	20.6	14.7
	US H7A	6520	22.4	14.6
	L.S.D. (5%)	537	1.5	0.5
Davis (Inoculated)	413H4	6720	24.7	13.6
	413H8	6820	24.7	13.8
	US H7	5000	18.8	13.3
	L.S.D. (5%)	600	1.9	0.6
413H4 = (562H0 x 569) x 5th sel. US 75				
413H8 = (562H0 x 546) x 5th sel. US 75				
US H7 = (562H0 x 569) x 663				
US H7A = (562H0 x 546) x 663				

Table 7. Gross sugar yields of yellows-resistant hybrids in 1966 California variety tests, expressed in the percent of the yield of US H7.

Location	13H4	13H8	44H4	44H11	34H11	37H4	37H8
Salinas - Inoc.	121	132	125	-	137	98	-
Salinas - Sprayed	135	121	118	136	130	110	104
Salinas - Sprayed	109	114	113	120	125	101	96
Salinas - Nat. inf.	131	139	126	135	148	-	119
Davis - Inoc.	134	136	130	127	-	111	-
Brawley - Early har.	122	139	124	131	136	103	111
Brawley - Late har.	135	142	-	138	-	-	-
El Centro	-	-	-	122	-	-	-
El Centro	-	-	-	122	-	-	-
San Ardo	-	-	-	110	-	-	-

Table 8. Sucrose percentage of yellows-resistant hybrids in 1966 California variety tests, expressed in percent of the sucrose percentage of US H7.

Location	13H4	13H8	44H4	44H11	34H11	37H4	37H8
Salinas - Inoc.	105	109	107	-	109	99	-
Salinas - Sprayed	106	105	102	102	106	99	96
Salinas - Sprayed	102	102	101	100	106	100	97
Salinas - Nat. inf.	99	97	101	98	99	-	98
Davis - Inoc.	102	104	105	102	-	101	-
Brawley - Early har.	101	101	105	104	106	100	102
Brawley - Late har.	102	104	-	101	-	-	-
El Centro	-	-	-	99	-	-	-
El Centro	-	-	-	100	-	-	-
San Ardo	-	-	-	96	-	-	-

13H4 = (562H0 x 569) x 413
 13H8 = (562H0 x 546) x 413
 44H4 = (562H0 x 569) x 544
 44H11 = (563H0 x 550) x 544

34H11 = (563H0 x 550) x 534
 37H4 = (562H0 x 569) x 437
 37H8 = (562H0 x 546) x 437

PERFORMANCE OF A SECOND SUCCESSIVE SELECTION FOR YELLOWS
RESISTANCE MADE ON THE BASIS OF THE RELATIVE CONCENTRATION
OF THREE AMINO ACIDS IN THE LEAVES OF INFECTED PLANTS

by

J. M. Fife

Sugarbeet plants were selected on the basis of the magnitude of the amino acid ratio (concentration: aspartic acid + glutamic acid)
glutamine

in the mature leaves of beet yellows-infected plants having a uniform root weight. First, second and third successive selections have been made and field tested. The methods used in making the selections have been reported (2). Seven years of field testing have shown that certain first, second and third successive selections are significantly more resistant to beet yellows than the parent variety, US 75, as shown by both the percent sucrose and yield of beets. The performance of the most promising selection made to date (a second successive selection) is summarized in this report.

Methods and Results

The tests were conducted at Spence Field, Salinas, California. The agronomic operations, including irrigation and the fertilizer program were the same as used for the other plot tests conducted the same year. The plantings were made in April and harvested in October. The growing period ranged from 162 to 180 days. All plants were inoculated with a virulent strain of the beet yellows virus 30 to 45 days after emergence. Insects, such as leaf miners, were controlled by spraying. The experimental design was a latin square with 2-row plots 50 feet long. Two 20-beet samples were taken from each plot for sucrose analysis. A summary of the tests are given in table 1.

In all tests, the increase in percentage sucrose of the selection, over that of the parent variety, was highly significant, the mean increase being 1.6 percentage points. Bennett (1) reported that, in plot tests conducted in the Salinas Valley in 1955, natural infection caused a reduction in tonnage of 22.3 percent and a reduction in sucrose of 1.38 percentage points. If the length of the growing season and cultural practices for the commercial plantings are maintained similar to that used for the testing of this selection, it appears that this selection may completely (or more than) restore the decrease in the percentage sucrose caused by natural infection in the Salinas Valley.

With the exception of the 1963 test, the yield of beets of the selection was significantly greater than that of the parent variety. The increased yields of sugar per acre of the selection, over that of the parent variety, was highly significant in all tests.

In the 1965 and 1966 tests, the plants were inoculated with a more virulent strain of the beet yellows virus than was used the two previous years. It appears that the more virulent strain did not affect the relative difference, in the sucrose percentage, between the selection and the parent variety. The yield of beets of the selection was increased relative to that of the parent variety, indicating that the selection may show even greater resistance (yield-wise) than the parent variety to the more virulent strains of the yellows virus and possibly to the more virulent strains of the virus that may occur under conditions of natural infection.

Table 1.

Summary of performance of a second successive yellows resistant selection relative to parent variety US 75.

Year		Sucrose		Acre Yield			
				Beets		Sugar	
		Ratio: RS-3 US 75		Ratio: RS-3 US 75		Ratio: RS-3 US 75	
		%	X 100	Tons	X 100	Pounds	X 100
1963	RS-3	14.3	109	15.0	108	4286	118
	US 75	13.1		13.9		3633	
1964	RS-3	17.6	112	9.8	118	3453	132
	US 75	15.7		8.3		2609	
1965	RS-3	15.5	112	11.6	127	3616	143
	US 75	13.8		9.1		2525	
1966	RS-3	16.8	111	11.8	133	3978	146
	US 75	15.2		8.9		2726	

Discussion and Summary

Four years of field testing has shown a second successive selection to have outstanding resistance to the more virulent strains of the beet yellows virus relative to that of the parent variety (US 75) both with regard to the percentage sucrose and the yield of beets. The mean percentage sucrose of the selection was 1.6 percentage points higher than the parent variety, which is highly significant.

If the length of the growing season and the cultural practices were the same for commercial plantings as that used in the tests, it appears that this selection may completely restore the decrease in the percentage sucrose caused by natural infection in the Salinas Valley.

The yield of beets was also significantly greater (approximately 20 percent) than the parent variety when virulent strains of the beet yellows virus were superimposed in the early stages of growth on virus strains of beet yellows and of beet western yellows by natural infection.

Some first selections and other second successive selections have also been shown to be significantly more resistant to beet yellows than the parent variety, with some first and second successive selections being tested for 7 and 4 years respectively.

By selecting plants, from large populations inoculated with a virulent strain of the beet yellows virus, on the basis of a superior amino acid ratio and a superior root weight, rapid progress toward resistance to beet yellows may be attained, both with respect to the percentage sucrose and to the yield of beets.

Literature Cited

- (1) Bennett, C. W. 1960. Sugar beet yellows disease in the United States. U. Dept. Agr. Tech. Bull. 1218.
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BREEDING FOR RESISTANCE TO SUGARBEET
NEMATODE HETERODERA SCHACHTII SCHM.

D. L. Doney and E. D. Whitney

The sugarbeet nematode Heterodera schachtii Schm. has long been one of the most destructive pests of the sugarbeet. This pest is found in nearly all the large sugarbeet areas of the world.

Much work has been done in the past years to screen and breed for nematode resistance, however, progress has been slow. In the 1965 progress report it was reported that the present techniques of screening were being confounded by the type and amount of micro-flora present. Therefore, it was felt that the best approach was to separate the nematode-root rotting complex into its component parts and study the known pathogens rather than the unknown complex. This work has been carried on rather closely with Dr. E. D. Whitney, part of which he reports elsewhere.

A technique for hatching and sterilizing nematode larvae in large enough quantities for a breeding program was developed. This technique is reported elsewhere in this report under, "Hatching and partial sterilization of the sugarbeet nematode, Heterodera schachtii Schm., in large quantities."

With this technique it was now possible to break the nematode-root rotting complex with its component parts and work on each one individually and in combination. This report will deal primarily with screening and testing for nematode effects. This research will be reported and discussed in the following order: (1) Screening for nematode resistance by cyst counts as a measure of infection rate; (2) Screening for nematode resistance based on the nematode effect on root yield; (3) The nematode effect on fibrous roots as a potential screening device; (4) The nematode effect on free amino acids in fibrous roots as a potential screening device.

A field trial was also conducted in nematode infested soil in 1966 and will be reported separately.

SCREENING FOR NEMATODE RESISTANCE BY CYST
COUNTS AS A MEASURE OF INFECTION RATE

Introduction

After a survey of the work of previous workers it was concluded that there does not exist a gene-for-gene type of resistance to the sugarbeet nematode in the cultivated sugarbeet as there exists in Beta patellaris. This gave rise to the question, "Is there a quantitative type of resistance to the sugarbeet nematode in the cultivated sugarbeet?" i.e., "Are there different levels of infection rate depending on the genotype?" If this is the case, these different levels of infection rate could be combined in a breeding program to gradually build up the

resistance to infection in the cultivated sugarbeet. Therefore, a screening technique and design was set up to test this possibility before an extensive selection and breeding program was undertaken.

Materials and methods

Technique of determining infection rate

Figure I shows the type of containers used. These were 15 and 50 dram-clear plastic vials with a hole punched in the bottom for drainage. The vials were filled with a dark sandy soil that gave very good aeration. In order to prevent the growth of algae along the sides, tops were placed on flats, and the vials placed into holes drilled through the tops as shown in Figure II. Seedlings were transplanted into these containers and allowed to grow from one to two weeks before inoculation. About 1500 sterilized larvae were added to the 15 dram vials and 3,000 sterilized larvae were added to the 50 dram vial when good root growth was observed around the periphery of the soilball as seen through the plastic vials. White female cysts began appearing between 2 to 3 weeks after inoculation, and were counted about 4 weeks after inoculation. Three studies were made in which the number of cysts on the periphery of the soilball was correlated with the total number of cysts on the plant and in the soil. In all three tests a correlation of .90 was obtained. Therefore, it was concluded that the number of cysts on the periphery of the soilball was a good measure of infection rate.

Selection of material

The material selected for these trials were as follows:

(1) Several of the best nematode tolerant selections; (2) Parents, if available, of the above mentioned selections; (3) Other open pollinated varieties having a broad genetic base; (4) A uniform hybrid and a homozygous line for estimation of environmental error.

It was desirable to test the infection rate of the tolerant selections with their parents, therefore materials one and two above were selected.

In attempting to evaluate a quantitative resistance and the measure of progress that can be expected by this means of selection, an estimate of the genotypic variance is necessary. When evaluating a heterozygous population on a per plant basis, the total phenotypic variation is a combination of the environmental variation plus the genotypic variation as illustrated below.

Phenotypic variation (Heterozygous) = $\text{Var } e + \text{Var } g$.

The total phenotypic variation of a homozygous population is just an estimate of the environmental variation as illustrated below.



Figure I. Clear plastic vials used for nematode counting. White dots along roots are white female cysts.



Figure II. Flats in which vials were placed.

Phenotypic variation (Homozygote) = $\text{Var } e$.

Thus by subtracting the phenotypic variation of the homozygous population from the phenotypic variation of the heterozygous population, an estimate of the genotypic variation is obtained which could be used to estimate the expected progress. An F test for the homogeneity of variance is the appropriate test for significant genotypic variance.

Results and discussion

A total of six tests have been conducted on most of this material. The mean nematode count on the periphery of the soilball for these selections in the six tests are shown in table I. Each one of these tests involved between 500 and 1500 plants.

As can be seen from table I, there exists a large variation from test to test. A variety low in infection rate in a particular test is not necessarily low in other tests. If it were possible to sum over all tests it appears there would be no difference between any of the entries.

In two tests there were a significant number of comparisons that were different. However, when testing at $P = .05$ and including all 6 tests one would expect 18 comparisons significantly different by chance alone. A total of 33 comparisons significantly different at $P = .05$ was obtained or 15 more than was expected. US 41, which has been used as a check, was the most consistently high entry. When comparing all other entries with US 41 a total of 4 comparisons were significantly less at $P = .05$; while one would expect 3 just by chance alone. Therefore, these extensive tests gave no good evidence to believe that one entry had a significantly lower infection rate than another.

One complication that may arise in screening by this method is that some genotypes may grow faster and thus have more roots available for nematode invasion. This would result in more cysts appearing on the faster growing genotypes and by selecting those with fewer cysts one would be, in effect, selecting for slower root growth. Therefore, correlations were made between root weight and nematode counts. This was done on 4 repeated tests of a population of about 1300 plants. Repeated tests were conducted by cleaning the tap root of all fibrous roots, retransplanting and reinoculating. Table II presents the correlations that were made. A significant correlation of .34 was obtained when the estimated root growth around the outside of the soilball at the time of inoculation was correlated with the resulting nematode count. In one case a good correlation was obtained between successive tests, but poor correlations were found in the other tests. There appeared to be some association between root weight and nematode count, especially the root weight prior to testing. However, there was a large variation between tests.

Table I. Mean number of nematode cysts on the periphery of the soilball.

Variety or selection	Parent or source	Tests					
		615	607	608b1	608b2	608a1	608a2
590-1	S2	50.4 ^a	123.9 ^a	27.1 ^a	138.1 ^{ab}	30.1 ^b	85.7 ^{bc}
S2	--	--	150.5 ^a	31.8 ^a	118.8 ^{ab}	9.2 ^a	87.8 ^{bc}
228-1	US 41	30.3 ^c	169.8 ^a	31.1 ^a	141.3 ^{ab}	15.3 ^{ab}	94.2 ^{abc}
US 41	--	42.0 ^{abc}	187.8 ^a	32.5 ^a	143.2 ^{ab}	11.0 ^a	109.0 ^{ab}
592-3	US 33	32.1 ^{bc}	149.1 ^a	28.8 ^a	141.1 ^{ab}	8.3 ^a	112.8 ^a
US 33	--	33.1 ^{bc}	160.6 ^a	33.0 ^a	131.1 ^{ab}	12.0 ^a	97.2 ^{abc}
594-2	US 22	29.1 ^c	116.6 ^a	29.1 ^a	173.0 ^a	15.8 ^{ab}	82.7 ^c
56-408	Amer. Crystal	37.8 ^{abc}	154.4 ^a	34.9 ^a	129.8 ^{ab}	12.6 ^a	114.9 ^a
Acc 107	Klein E mix [*]	45.8 ^{ab}	189.8 ^a	33.2 ^a	108.9 ^b	7.1 ^a	107.2 ^{ab}
62-9134, F ₁	R. Hecker	--	189.4 ^a	28.9 ^a	107.3 ^b	--	--
C5600	B. Hammond	12.7 ^d	150.4 ^a	29.8 ^a	92.1 ^b	15.4 ^{ab}	106.4 ^{ab}
US 15	--	41.8 ^{abc}	--	33.5 ^a	157.7 ^{ab}	10.2 ^a	--

Note: Any two means followed by the same letter are not significantly different at P = .05.

* A mixture of nematode tolerant lines from Klein E seed obtained from G. J. Curtis, Cambridge, England.

Table II. Correlations between nematode counts and root weights.

Correlations	r
Est. rt. growth at inoculation time x nema. count	.34*
1st nema. count x 2nd nema. count	.23
2nd nema. count x 3rd nema. count	.20
3rd nema. count x 4th nema. count	.64**
rt. wt. (2nd test) x nema. count (2nd test)	.24*
rt. wt. (2nd test) x nema. count (3rd test)	.50**
rt. wt. (3rd test) x nema. count (4th test)	.22
rt. wt. (4th test) x nema. count (4th test)	.36

* Significant at $P = .05$.

** Significant at $P = .01$.

The estimated environmental and genotypic variances are presented in table III. The phenotypic variance of the heterozygous population was larger than that of the homozygous populations in only two tests. In no test was there a significant genotypic variation due to infection rate. This means that there does not exist a genotypic variance for infection rate in these populations or that the environmental error was so great the genotypic variance could not be detected. If there is no genotypic variation, there is no quantitative type of resistance to infection rate and selection based on this technique would result in little or no progress.

To further test these results a selection scheme was set up in a population of 1300 plants of several heterozygous lines. From this population 215 plants were selected that had zero or less than 10 cysts on the periphery of the soilball. Another population of 75 plants with high cyst counts were also selected. These plants were tested in two more successive tests for infection rate. The results are shown in table IV. After two successive tests the population having the fewest nematodes in the first test had the same infection rate as the population with the highest infection rate in the first test.

Similar work is being conducted to test other heterozygous populations of divergent germ plasm.

Table III. Environmental and genotypic variance estimates for nematode infection rate.

<u>Population</u>	<u>Variance Component</u>	<u>Experiment No.</u>				
		<u>7</u>	<u>8a1</u>	<u>8a2</u>	<u>8b1</u>	<u>8b2</u>
Hom.	Var E	8,254	178	3,077	350	9,208
Het.	Var E + Var G	6,063	211	2,642	277	11,222

Note: Var E = Environmental variance

Var G = Genotypic variance

Table IV. Selection for nematode resistance from an initial population of 1,300 plants.

<u>No.</u>	<u>\bar{x} count of Resistant selections</u>	<u>No.</u>	<u>\bar{x} count of Susceptible selections</u>	<u>Test</u>
215	5.98	75	56.60	1
207	63.50	73	81.64	2
203	50.60	73	49.60	3

SCREENING FOR NEMATODE RESISTANCE BASED ON THE NEMATODE EFFECT ON ROOT YIELD

Since the technique was now available to study the effect of nematodes on yield without the complicating factor of the associated root-rotting pathogens, a program was initiated to test the merits of screening for resistance based on root weight in the greenhouse.

Methods and materials

Three tests were conducted in 50 gram plastic vials. A uniform hybrid was used in experiment 610a and 610b and half of the plants inoculated with about 8,000 sterilized larvae. Experiment 610a was harvested one month after inoculation and experiment 610b was harvested two months after inoculation. The material used in experiment 607 consisted of 10 different heterozygous lines and two homozygous lines for an estimate of the environmental error. One half of the plants were inoculated with 4,000 sterilized larvae 2 weeks after transplanting. Tap root weights were taken six weeks after inoculation.

Another test was conducted in 8" clay pots and the plants allowed to grow for 120 days following inoculation. Twenty four plants each of 590-9, (a nematode selection), S2 (the parent of 590-9), HF₁ (a uniform hybrid) and 52-305 (a highly inbred line) were planted in 8" clay pots. Two weeks after emergence 1,000 nematode were added to 12 plants of each entry. Larvae were then added to these plants for about one month until the total number added per plant was about 45,000. After 120 days of growth the plants were harvested and weighed. A soil sample was also taken from each pot to determine the nematode build-up.

Results and discussion

The results of these tests are presented in table V. There was no effect on root weight after one month (exp. 610a), however, after two months there was a significant reduction in root weight due to nematodes (exp. 610b). Experiment 607 was harvested about 6 weeks after inoculation and showed a slight but not significant reduction in root weight. The more important statistic here is the significant genotypic variance obtained. This means that progress could be made by selecting for root weight in these small containers in the greenhouse. However, it also indicates that one month is not long enough to observe differences.

Experiment 609, which was allowed to grow longer, gave the more reliable results.

A significant reduction in root weight due to nematodes was recorded in all entries except the hybrid. It is interesting to note that the percent loss was around 10 to 15 percent. This is much less than that observed in commercial fields. Varieties that yielded best in nematode soil also yielded best in clean soil. Here again a significant genotypic variance was obtained, indicating progress could also be achieved by this method. It appears that the use of larger containers with a longer growing period will give more reliable results.

An extremely high nematode population developed in experiment 609, with an average of 696 cysts per 100 grams of soil. When the nematodes left on and/or in the sugarbeet were included with those in the soil, it was estimated that each beet was invaded with approximately 70,000 to 100,000 larvae. It is significant to note that under these conditions of high nematode infestation little or no killing of plants occurred.

Table V. Effect of nematodes on root weight

<u>Test</u>	<u>Clean soil wt (g)</u>	<u>Nema. soil wt (g)</u>	<u>% Loss</u>	<u>Var E</u>	<u>Var E + Var G</u>	<u>Nematode cysts per 100 grams of soil</u>
607	2.96	2.82	7.2	.438	.759 ^b	
610a	.545	.537	1.5			
610b	2.46	1.92	22.0 ^a			
609	142.3	124.1	12.8 ^a	449	1,165 ^b	696
HF1	124.0	113.5	8.5	725		
590-9	198.1	172.5	12.9 ^a		1,224 ^b	
S2	157.0	136.1	13.3 ^a		1,105 ^b	
52-305	90.1	74.3	17.6 ^a	174		

a = Significantly less at P = .05

b = Significant Var G at P = .01

THE NEMATODE EFFECT ON FIBROUS ROOTS AS A POTENTIAL SCREENING DEVICE

It has long been observed that hairy roots are associated with nematode infestations. These observations have always been in the field where the nematode-root rotting complex was present.

It was desirable to see if this effect was a result of the nematodes, the associated pathogens, or the complex.

Materials and methods

Four tests were conducted where half of the plants were inoculated with sterilized nematode larvae. Six weeks after inoculation the roots were washed clean of soil and weights taken on the fibrous roots. One test showed a significant increase in fibrous roots, while very little increase in fibrous roots due to nematodes was observed in the other three tests.

It was observed that many more new coarse white roots appeared on the plants grown in vials which were inoculated with nematodes than on the noninoculated plants. A further check confirmed these observations. Therefore, two tests of 800 plants each were set up to further examine this phenomenon. The plant materials used were similar to those used in testing nematode infection rates.

Plants in test 607 were grown in 50 dram vials, while plants in test 615 were grown in 15 dram vials. When roots appeared on the outside of the soilball, one half of the plants were inoculated with sterilized larvae. Plants in test 607 were inoculated with 4,000 larvae each. Plants in test 615 were inoculated with 1500 larvae each. Six weeks after inoculation each plant was given a coarse root rating. This rating ranged from one to six (one meaning no coarse roots and six meaning many coarse roots). A completely randomized design was used.

Results

The results of these two tests are shown in table VI. It can be seen that there was a significant increase in coarse roots due to nematode invasion in both tests.

The nematode effects on coarse roots were separated into variety effects and presented in table VII. There was considerable variation among varieties for nematode effect on coarse roots. It was encouraging to see that with the exception of two varieties the effects were relatively consistent for varieties over the two tests.

It appears as if this character is genetically controlled, i.e. some varieties are stimulated to send out more new coarse roots as a result of nematode invasion than other varieties.

Selections will be made in this material and tested further in the greenhouse as well as in the field to determine the merits of selecting genotypes that are not stimulated to produce coarse roots as a result of nematode invasion.

Table VI. Effect of nematodes on coarse roots

Test	Rating for coarse roots		
	Clean	Nematode	Nema. effect
615	1049	1308	259
607	169	426	257

Table VII. Effect of nematodes
on coarse roots by variety

Variety	Test 615	Test 607
590-1	23	23
S2	--	28
592-3	44	50
US 33	42	6
228-1	8	--
US 41	23	26
US 15	34	--
594-2	45	30
56-408	16	16
Acc 107	34	11
C5600	-12	9
HF1	--	33

THE NEMATODE EFFECT ON FREE AMINO ACIDS IN FIBROUS ROOTS AS A POTENTIAL SCREENING DEVICE

(This work was done in cooperation with Dr. J. M. Fife)

Various investigators believe that nematode larvae feeding inside the root give off certain enzymes that upset the metabolism of the plant. In like manner resistant plants would not be affected by these enzymes or to a lesser extent than susceptible plants. An upset in the metabolism of the plant can be detected by measuring the change in the free amino acid pattern. In addition, this upset might be reflected in the free amino acids in the root diffusate.

Methods and materials

Two tests were set up to study this approach. The first test (test 601) consisted of three selections, Beta patellaris (a resistant species), US 41 (a susceptible variety), and 063 (a tolerant selection). Twenty plants of each selection were planted in 3 inch pots containing sterile sand and watered with Hoagland's solution. Two weeks after transplanting, 2,000 sterilized larvae were added to 10 plants of each of the three entries. One week after inoculation root diffusate was taken from each plant by leaching 100 ml. of distilled water through each pot in an eight hour period. Two weeks after inoculation fibrous roots and leaf samples were taken from each plant and the juice expressed from each sample for amino acid analysis.

The root diffusate was analyzed for total amino acids. Data taken on the leaf and fibrous juice were total amino acids, aspartic acid, glutamic acid and glutamine. Data are expressed in milligram percent. Duplicate tests were conducted on all samples. A completely randomized design was used.

The second test (test 610) was conducted in 50 dram vials with 62-9134 (a uniform hybrid) as the test material. A dark sandy soil was used instead of sand. Two weeks after transplanting 35 of the 70 plants were inoculated with 8,000 sterilized nematode larvae each. Six weeks after inoculation the fibrous roots were taken, the juice expressed from each, and tested for the concentration of aspartic acid, glutamic acid, and glutamine.

Results and discussion

The analysis of variance and F tests for the first experiment are presented in table VIII. The test of treatments in the analysis is the difference between healthy and infected plants summed over all three selections. Only the total amino acid in root diffusate and the glutamic acid in fibrous root juice gave significant treatment differences, however, several other amino acids approached significance.

The treatment times selection interaction, if significant, indicates a difference in reaction to infection of the three entries. An effect, in order to be useful as a screening tool, would be significant in the susceptible entries but of no significance in B. patellaris. A significant treatment times selection interaction would detect this. Aspartic acid in root juice was the only amino acid in which a significant interaction was obtained, however, glutamic acid in root juice approached significance at the 5 percent level. It appeared as if the nematode effects were more pronounced in the fibrous roots. Therefore, the treatment times selections interaction for fibrous roots was partitioned and analyzed. These data are in table IX.

The important comparison here is that there were no effects or differences due to nematodes for B. patellaris, while significant increases in both aspartic acid and glutamic acid due to nematodes were observed for the other two entries. When US 41 and O63 were combined, highly significant increases in these two amino acids were found.

These results were further confirmed by the second experiment, the results of which are presented in table X. In this case highly significant increases in aspartic and glutamic acid and significant increases in glutamine in the expressed juice of the fibrous roots were found as a result of nematode infection.

The two tests were different in that, the second test was conducted in a sandy soil with a uniform hybrid while the first test was in sand with heterozygous populations.

With these two tests confirming each other a larger more extensive test was designed to find out the feasibility of selecting for nematode resistance using these three amino acids as a selection criterion. This test is not yet completed.

Table IX. Effect of nematodes on free amino acids in the fibrous roots of B. patellaris, US 41 and 063

<u>Var.</u>		<u>Aspartic</u>	<u>Glutamic</u>	<u>Glutamine</u>	<u>Complex</u>
B. pat.	clean	3.54	5.66	20.98	5.92
	inoc.	2.35	5.82	22.63	5.20
US 41	clean	4.66	13.40	54.50	8.52
	inoc.	6.24*	17.35	62.02	7.20
063	clean	5.24	10.40	36.20	5.88
	inoc.	6.96*	16.79**	61.10	8.20
US 41) +) 063)	clean	4.95	11.90	45.35	7.20
	inoc.	6.60**	17.07**	61.56	7.70

* = Significant increase at P = .05

** = Significant increase at P = .01

Table X. Effect of nematodes on three amino acids in the fibrous roots of 62-9134 (a uniform hybrid)

	<u>Aspartic</u>	<u>Glutamic</u>	<u>Glutamine</u>
Clean	1.96	2.19	2.64
Inoc.	2.85**	3.70**	4.75*

* = Significant increase at P = .05

** = Significant increase at P = .01

1966 FIELD TRIAL OF SELECTIONS AND PARENTS

A very strong selection pressure was exerted on the existing nematode selections and out of these 12 were selected for further testing in 1966.

Prior to planting, nematode counts were taken over the entire nematode field. This was done to determine the nematode distribution in the field. There appeared to be a slight gradient in two directions, therefore, the experimental design chosen was a latin square.

Nine selections with their parents were selected for testing. A hybrid, US H7, was also included in this trial making a total of 14 entries in a 14 x 14 latin square. Plots consisted of 4 ten foot rows. The trial was planted April 7, plants were thinned to ten inches on June 4, and the trial harvested on October 19. Surviving plants after thinning and plants at harvest time were counted. At harvest time the two center and two outside rows of each plot were weighed separately. After each plot was weighed in the field it was bagged and taken to the lab. where it was trimmed, washed, reweighed, and tested for sucrose percentage.

Analyses were made on sucrose, clean weight, field weight, yield of two center rows, and yield of outside two rows. Correlations were made on inside times outside rows and weight times number of roots.

Results

In all results highly significant row and column effects were obtained indicating a good design. Table XI gives the results of the trial based on clean weights. Also shown in table XI are the number of beets at harvest time, the number of beets lost or dying between thinning and harvest, and the average weight per root for each entry. It was believed that some of the more tolerant lines would have fewer sprangled and hairy roots and this could be detected by comparing the differences in tare. Therefore, analyses were made on the clean weight as well as the field weight. However, there was very little difference in tare from selection to selection and the field weights gave essentially the same information as the clean weights. A little more precision was obtained on clean weights, therefore, the clean weights are shown in table XI.

Competition between neighboring unlike genotypes can confound the results. Therefore, analyses were made for the two center rows and the two outside rows separately. These analyses indicate no difference in yield and variation between the outside and inside rows, suggesting very little genotypic competition in this trial. Good correlations were obtained for yield and number of beets between center and outside rows.

Table XI. Field trial of selections and parents, 1966

Entry	Code	Parent	Mean Sucrose %	Mean Clean Wt. Tons/Acre	Tons Sucrose Per Acre	No. Beets at Harvest	No. of Beets Lost ^a	Mean Wt./Root
590-1	134-H8	S2	15.6	12.6	1.96	673	44	.79
590-9	054-1	S2	15.7	15.0	2.35	708	8	.90
S2	--	--	14.6	9.8	1.43	608	115	.69
56-408	033-1	not-known	15.5	12.9	2.00	610	113	.90
592-1	159-8	US 33	16.2	14.0	2.27	726	8	.82
592-3	861-15	US 33	15.8	11.9	1.88	657	44	.77
592-7	101-7	US 33	15.5	11.0	1.71	515	111	.90
US 33	--	--	16.7	13.2	2.20	631	71	.89
594-2	063	US 22	15.3	13.3	2.04	705	14	.80
US 22	--	--	15.9	11.5	1.83	704	42	.69
591-2	0057-15	US 56	15.0	11.0	1.65	669	79	.70
228-B1	228-B1	US 41	15.5	12.8	1.99	671	40	.79
US 41	--	--	15.4	12.6	1.94	720	32	.74
US H7	--	--	14.9	9.6	1.43	573	203	.71
LSD .05	--	--	0.5	1.46	.264	53.2	--	--
LSD .01	--	--	0.65	1.90	.343	68.6	--	--

^aNo. of surviving beets at thinning time minus the no. of surviving beets at harvest time.

Both selections out of S2 yielded significantly better than the parent in both yield and sucrose percentage. Of the three selections tested out of US 33, only one (592-1) yielded better than US 33 and it was not significantly better. The other two selections gave significantly poorer yields than their parent. The selection out of US 22 yielded significantly better than its parent but had poorer sucrose, which resulted in no significant increase in sucrose per acre over its parent. The selection from US 41 likewise was not different from its parent.

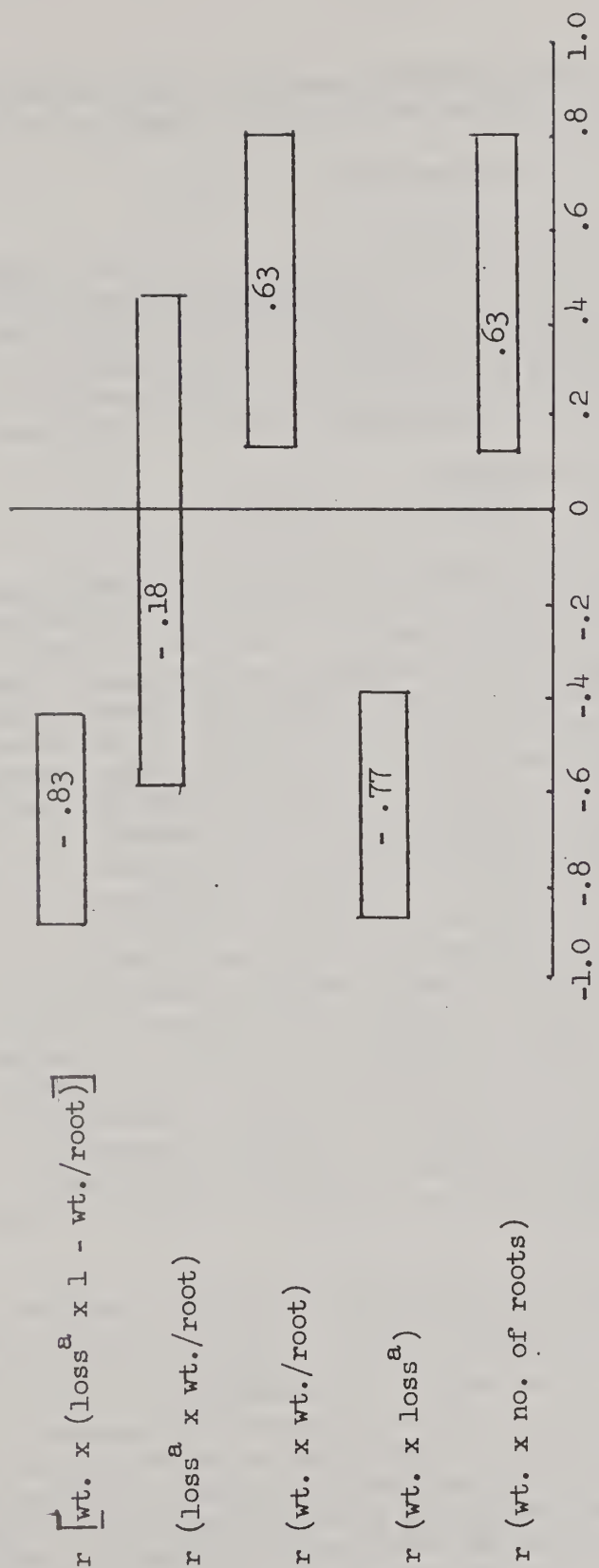
The interesting entry here is US H7 which is used somewhat commercially. It was not only the poorest in yield but poorest in sucrose percentage. When the surviving plants after thinning count was taken there were significantly more plants of US H7 than any other entry, but at harvest time there was only one other entry with fewer roots.

Discussion

In an attempt to separate the factors involved in nematode resistance, several correlations were made and are shown in figure I with their respective confidence interval. Whenever a confidence interval crosses the zero line the correlation is not significantly different from zero. Correlations of yield times number of roots and yield times weight per root were significant and positive with a correlation of .63. When the loss or the number of roots dying between thinning and harvest time was correlated with yield a correlation of -.77 was obtained. It is interesting to note that there was no correlation between weight per root and loss, even though they were both correlated with yield, but when they were combined and correlated with yield a correlation of -.83 resulted. This indicates that these are important yield factors in nematode infested soils and they are independent of each other, but when combined they account for about 70 percent of the variation in yield.

In attempting to understand these effects in terms of nematode resistance, it seems reasonable to assume that the factor of weight per root is a tolerance or vigor factor. However, this is hard to define. In results reported elsewhere in this report, no evidence was found to indicate that nematodes kill plants. Therefore, it is believed that the loss of roots is not the results of nematodes themselves, but the result of their association with root rotting fungi. Those selections that yielded better than their parents were better than their parents in one or both of these factors.

Figure 1. Correlations and confidence intervals



^aLoss = roots dying between thinning and harvest.

THE EFFECT OF THE SUGARBEET NEMATODE, OTHER ORGANISMS
AND A COMPLEX OF THE TWO ON YIELD AND SPRANGLING OF ROOTS

E. D. Whitney and D. L. Doney

The question, as to the relative importance of each organism in the sugarbeet root-rot complex (i.e. Heterodera schachtii Schm. and fungi) was partially answered by the work of Price and Schneider (3). Their study did not evaluate the importance of the addition of nematodes to soils in which the micro-flora and micro-fauna had developed under sugarbeet production. This paper reports the results of such a study.

Materials and methods:

Three soils found to be free of the sugarbeet nematode were selected and designated as soils 1, 2, and 3. The soil type and cropping sequence of each soil is given in Table I. One-half of each soil was steam-treated (autoclaved) for 7 hrs. at 5 lbs. pressure. Each soil was thoroughly mixed, potted in 3 gal. crocks and placed on concrete blocks to avoid contact with the soil. A completely randomized design was used. Each treatment was replicated 25 times. The treatments were: autoclaved soil, autoclaved soil to which nematodes were added, field soil and field soil to which nematodes were added. The experiment was conducted under field conditions. Two varieties of sugarbeets, S₂ and hybrid (F58-554H1) were surface disinfested for 20 min. with a 1000 ppm solution of mercuric chloride and planted in each crock. Three weeks after planting each crock was thinned to 2 plants of one variety with each variety nearly equally represented for each treatment. Those treatments to include nematodes were inoculated with 1000 sugarbeet larvae surface sterilized for 72 hrs. as reported in the section "Hatching and Partial Sterilization of the Sugarbeet Nematode, H. schachtii Schm. in Large Quantities." Each week for 4 weeks following the initial inoculation, plants in appropriate crocks of soil received an increasing number of sterilized nematodes; 2000, 4000, 8000, and 9600. The crocks were thinned to 1 plant between the second and third inoculation.

The beets were harvested 145 days after planting, weighed, checked for root sprangling and soil samples taken. Ten 100 g samples were wet screened and the number of cysts counted to determine the population build-up in soils having larvae added. Four samples from each field soil were treated similarly. A composite sample from several crocks taken at random for each field soil was taken to determine the damping-off fungi in the soils following beet production. An equal number of surface disinfested beet seeds were planted in each soil. Those damping-off were bioassayed by the water culture method for pathogenic fungi. A sample of soil 3 from the original site which had been fallowed was treated similarly.

Table I. Soil type and cropping sequence for each soil.

Soil	Soil Type	Cropping sequence				
		1965	1964	1963	1962	1956
1	Camphora sandy clay loam	Nasturtiums	Barley	Beets	----	----
2	Chualar sandy loam	Barley/vetch	Fallow	Barley	Fallow	Beets
3	Camphora sandy clay loam	Beets	Beans	Barley	Beets	----

Results:

The number of beets harvested for each treatment differed due to damping-off or poor germination. An analysis of the yield data showed a highly significant difference due to soils, treatments, varieties and soils times treatments. When summing over soils there was a highly significant yield effect due to autoclaving with the beet yield highest in the autoclaved soils. There was no effect due to nematodes nor was there an interaction which would have indicated a synergistic effect. The test of soils times nematodes was highly significant which indicated an effect due to nematodes in 1 soil but not in the others. Soils 1 and 2 appeared to react similarly to all treatments with the only loss being due to soil organisms other than nematodes, Table II. Soil 3 which reacted differently had losses due to nematodes, other soil organisms and a seemingly more than additive effect when a combination of the two existed, Table II. An analysis of the yield data for soil 3, however, did not show an interaction when the treatment effects were partitioned.

The percent of sprangled roots did not increase with the addition of nematodes to the autoclaved soils nor to field soils 1 and 2. There was an increase in percent of roots sprangling in the field soils and a more than additive increase in field soil 3 when nematodes were added, Table II. The greatest loss in weight of sprangled roots occurred in field soil 3 to which nematodes had been added.

The total number of plants damping-off, the number of plants and the percent damping-off from each organism are listed in Table III. The predominant damping-off fungus in soils 1 and 2 was Pythium ultimum Trow. Approximately equal numbers damped-off in soils 3 from P. ultimum and Aphanomyces cochlioides Drechs. The predominant fungus causing damping-off in soil 3 from the original site was A. cochlioides, Table III.

The mean number of cysts per 100 g of soil recovered from each soil to which nematode larvae were added are listed in Table IV. A significantly larger number of cysts developed on plants grown in autoclaved soil 3 to which nematode larvae were added. When the field soil was sampled at the end of the growing season 6 cysts from 12 samples (4 samples from each soil) were found. Two of the cysts were full of eggs, 1 partly full, and 3 empty. The mean number of cysts recovered per 100 g of soil are listed in Table IV.

Discussion:

Although statistically a synergistic effect due to nematodes plus soil organisms in soil 3 was not shown, it seems more than coincidental that the loss due to this treatment as well as the percent increase in number of plants with sprangled roots was more than additive. This additional loss appears to be due to A. cochlioides as the number of plants damping-off from P. ultimum was essentially the same for all 3 soils. This, however, may be incorrect as it is

possible an interaction of all 3 occurred or the losses were due to other organisms in the soil. It has been suggested that sprangling of roots (2) or lack of tap root (1) of sugarbeet is caused by nematodes. These data show that the nematode does not cause the sprangling of roots but may increase this number in the presence of other organisms. This appears to be the system under which the first mentioned work was carried out as they used "tare dirt" in which to grow the sugarbeets. The large number of cysts found in autoclaved soil 3 shows that large populations of nematodes are required to cause a substantial decrease in yield which is common knowledge and further supported by data in the section "Screening for Nematode Resistance Based on the Nematode Effect on Root Yield" reported by D. L. Doney. This large difference in the number of female nematodes developing to maturity is not readily apparent but may be from several causes among which may be poor plant growth or predaceous organisms in soil 3 not found in soils 1 and 2. Although a small number of cysts were found in the field soils after the growing season it is unlikely that they effected the results substantially. The difference in the cyst population of autoclaved soils 1 and 3 is not easily explained as the soil types are the same, however, they were from different sites.

These data would suggest that more emphasis should be placed on rotations that reduce the pathogenic populations of fungi as well as the nematode, as it seems apparent that only low populations of nematodes are required to result in great losses when associated with other soil organisms.

Literature cited:

1. Jones, F. G. W. 1965. Beet Eelworm. Plant Nematology. (Edited by J. F. Southey). Her Majesty's Stationery Office, pp 189-198.
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3. Price, Charles and C. L. Schneider. 1965. Heterodera schachtii in relation to damage from root rot of sugar beets. Proc. Am. Soc. Sugar Beet Technol. 13 (7): 604-606.

Table II. The effect of nematodes, soil organisms, and nematodes plus soil organisms on yield and sprangling of roots in three soils.

Soil treatments	Soil 1				Soil 2				Soil 3			
	Autoclaved		Field		Autoclaved		Field		Autoclaved		Field	
	None	Nema.	None	Nema.	None	Nema.	None	Nema.	None	Nema.	None	Nema.
\bar{x} root wt. gms.	183.1	184.2	163.3	172.1	91.6	114.3	75.1	70.2	151.9	120.5	104.0	58.3
\bar{x} wt. loss gms.	-----	0.0	19.8	11.1	-----	0.0	16.5	21.4	-----	31.4	47.9	93.6
% loss of wt.	-----	0.0	10.8	6.0	-----	0.0	18.0	23.4	-----	20.7	31.5	61.6
No. sprangled roots/ no. harvested	1/25	1/24	4/23	5/24	2/23	2/23	4/24	3/25	2/20	2/23	8/25	15/23
% sprangled roots	4.0	4.2	17.4	20.8	8.7	8.7	16.7	12.0	10.0	8.7	34.8	65.2

Table III. The total number of sugarbeets damping-off, number and percent from each cause.

Soil	Total	<u>P. ultimum</u>	<u>A. cochlloides</u>	Unknown
1 ^a	89	77 86.5%	5 5.6%	7 7.9%
2 ^a	100	87 87.0%	5 5.0%	8 8.0%
3 ^a	163	85 52.1%	78 47.9%	0 0.0%
3 ^b	54	9 16.7%	41 75.9%	4 7.4%

^a Soil from crocks .

^b Soil from the original site

Table IV. Number of cysts per 100 gms. of soil developing on sugarbeets.

	Soil 1		Soil 2		Soil 3	
	<u>Autoclaved</u>	<u>Field</u>	<u>Autoclaved</u>	<u>Field</u>	<u>Autoclaved</u>	<u>Field</u>
Soil treatments	None	Nema.	None	Nema.	None	Nema.
Other treatment	None	Nema.	None	Nema.	None	Nema.
\bar{x} number of cysts per 100 gms. soil	----- 12.6 ^a	.75 10.7 ^a	----- 8.6 ^a	.25 12.3 ^a	----- 51.4 ^b	.50 2.3 ^a

Any 2 treatments followed by the same letter are not different at $P = .05$

HATCHING AND PARTIAL STERILIZATION OF THE SUGARBEET NEMATODE, HETERODERA SCHACHTII SCHM. IN LARGE QUANTITIES

E. D. Whitney and D. L. Doney

Introduction:

Greenhouse studies (3) indicate that progress in selecting for resistance to the sugarbeet nematode Heterodera schachtii Schm., is slow when selections are made from plants grown in soils with high populations of both the nematode and fungi.

It therefore became apparent that it would be desirable to eliminate soil contaminants from nematode larval inoculum to study the root-rot complex of sugarbeets and to evaluate sugarbeets for resistance.

Clark and Shepherd (1) reported in 1965 that zinc chloride and other metallic ions were hatching agents for H. schachtii Schm. It was shown by Moriarty (2) that H. schachtii Schm. could be surface sterilized after hatching by immersing the larvae for 72 hrs. in a solution containing 10 ppm ethoxyethyl mercury chloride, 0.01% dioctyl sodium sulphosuccinate and Crystamycin (1000 units Sodium penicillin G plus 1 mg streptomycin per ml). These reports suggested the possibility of hatching and sterilizing nematodes simultaneously.

Materials and methods:

Sugarbeet nematode cysts were wet screened from the soil or sand by passing the floating material, after a 10 sec. settling period, over a nested 20 and 60 mesh screens. The large organic debris is retained on the top 20 mesh screen and the cysts plus the finer material collected on the 60 mesh screen. This material is placed in a hatching pan. The hatching pan consists of two nested 9 inch stainless steel pie pans. The center 6 inches of the bottom of the top pie pan has been replaced by No. 10 mesh stainless steel screen soldered to the bottom of the pan. Three small spots of solder are placed on the rim of the bottom pan to separate the two pans. A moist milk filter pad (Rapid Flow) is placed over the screen of the top pie pan Fig. 1 and the cyst containing material poured onto the filter pad. The water in the bottom pan is then replaced with enough hatching solution to just cover the screen bottom of the top pan.

Hatching solution:

Zinc chloride	4mM
Ethoxyethyl mercury chloride	10ppm (Aretan)
Dioctyl sodium sulphosuccinate	0.01% (Vatsol OT)
Streptomycin sulfate USP Grade B	1 mg / ml
Penicillin G potassium USP Grade B	1000 units / ml

The hatching pans are placed in a hatching cabinet constructed in cooperation with Mr. A. E. Steele, Nematologist, to study factors affecting the hatching of H. schachtii Schm. The hatching cabinet is a reconditioned meat cooler providing temperature control for constant and diurnal temperatures by reverse cycling of the refrigerant for heating and regular cycling for cooling. High humidity is maintained in the cabinet (2 x 6 x 7 ft.) by a one-half minute injection of water every 6 min. through 2 spray nozzles delivering 2 gal. / hr.

The nematodes upon hatching crawl through the filter pad and are collected in the bottom pan free of debris.

To determine the effects of hatching solutions on the rate of hatch and on the infectivity of larvae, four hatching solutions were tested, 1) root exudate, 2) root exudate plus additive (regular hatching solution without zinc chloride, 3) zinc chloride, and 4) hatching solution. The screened cysts were aliquoted onto each filter pad at random. Each treatment had three replications. To remove as many nematodes of other genera as possible, the hatching pans were filled with water for 48 hrs. and the nematodes found in the bottom pan were discarded. The pans were then filled with hatching solution and placed in the hatching cabinet for 5 days at alternating temperatures of 60 F. for 15 hrs. and 75 F. for 8 hrs. with two 30 min. periods of temperature change. Following hatching, enough sterile water was added to the nematodes in each pan to make a total of 500 ml. The total number of larvae was determined by counting three one-half ml. samples from each replication. The mean number of nematodes from the three pans was used to estimate the number of larvae hatched per treatment.

To determine the infectivity of the nematodes from each treatment, four replications of five sugarbeet plants (hybrid F58-554HL) each grown in sand in an individual container were inoculated with approximately 2000 larvae per plant in 10 ml of the diluted solution. Mineral nutrition was provided by Hoagland's solution.

One ml. of solution from each treatment diluted 10^{-1} , 10^{-2} and 10^{-3} was plated on potato-dextrose agar to determine the effectiveness of the fungicide and antibiotics in eliminating the fungi and bacteria from each treatment.

To test the longevity of the nematodes in vitro, aliquots of 10,000 larvae in 50 ml. of the diluted hatching solutions were placed in petri dishes and stored at room temperature in the dark and under refrigeration. Each week 2 aliquots of the nematodes from each treatment were used to inoculate 10 hybrid sugarbeet plants (2 replications of 5 plants) at the rate of 2000 nematodes per plant in 10 ml. of diluted solution. Each plant was grown in sand in an individual container with Hoagland's solution added to provide the necessary minerals. Ten days after inoculation the plant roots were washed free of sand, stained in hot Lactophenol acid fuchsin for 1 min. and the number of nematodes infecting the roots of each plant counted.

Although the hatching of larvae in sterilants resulted in a reduction in contamination it was apparent that further sterilization of the larvae was necessary. A test was conducted to evaluate the feasibility of using the same sterilants as a second treatment. Hatched larvae from hand picked cysts hatched over a period of 72 hrs. were screened from the hatching solution and washed from the sieve with sterile water. The larvae were then aliquoted into 6 beakers and screened a second time. One beaker of nematodes was washed from the sieve with water into a petri dish and retained as a check. The remaining 5 beakers containing nematodes were individually screened and washed from the sieve with the sterilizing solution into petri dishes.

To test the decrease in contamination of the larval suspension with each additional 24 hrs. of treatment a 1 ml. sample was taken from the check at the beginning of the test and one from one of the remaining petri dishes of nematodes each day for 5 days. These samples were placed in 9 ml. of sterile water. Also at the end of each 24 hr. period the petri dish of nematodes sampled for the sterility test was screened from the sterilizing solution and placed in sterile water in a petri dish to test the loss of infectivity of the larvae due to length of treatment.

The sterility of each treatment was tested by placing 1 ml. of the 10^{-1} solution one each of 2 petri dishes of potato dextrose agar and in 4 test tubes each of 9 ml. of N I H and Sabaroud Broth. The infectivity of the larvae from each treatment was tested by inoculating 24, 3 week old hybrid sugarbeet plants (F58-554H1) with 750 larvae. The plants were grown at 24 C in a controlled environment chamber with a 16 hr. photo period. Eight days after inoculation the sugarbeet roots were stained and the nematodes counted as previously described. The test was repeated once.

Results:

The total number of larvae hatched in five days in root exudate, root exudate plus additive, zinc chloride and zinc chloride plus additive was 820,500; 1,171,500; 352,500; and 541,500 respectively. An analysis of the data showed that root exudate was superior to zinc chloride as a hatching agent. The difference was highly significant. It also showed a highly significant increase in hatch when the additive was included in the hatching solutions. There was no interaction between the hatch factors and additive, indicating the stimulating effect of the additive was similar in both cases.

Infectivity studies indicated that more infections occurred when zinc chloride was the hatch factor, as well as when the additive was used. These increases were significant at the 10 percent level, Table I. These differences were not apparent after one week's storage of the nematodes.

Table I. Mean number of larvae infecting each plant when inoculated at the time of hatching and when inoculum is stored under refrigeration and room temperature for a period of 4 weeks.

	<u>Treatments</u>			
	1	2	3	4
0 week*	349.2	439.9	436.1	495.3
<u>Refrigerated</u>				
Wk. 1**	758.6	357.7	577.4	551.5
Wk. 2**	450.6	508.3	505.7	596.5
Wk. 3**	466.7	376.2	530.3	537.2
Wk. 4**	542.9	558.4	588.3	641.3
Total No. of infections	22,188	18,006	22,017	23,265
<u>Room temperature</u>				
Wk. 1**	549.4	534.6	621.7	527.7
Wk. 2**	577.3	301.6	628.0	317.7
Wk. 3**	432.1	146.3	430.9	153.0
Wk. 4**	297.0	110.7	294.0	91.4
Total No. of infections	18,558	10,932	19,746	10,898

Treatments

- 1 - Root exudate
- 2 - Root exudate plus additives
- 3 - Zinc chloride
- 4 - Zinc chloride plus additives

*Mean of four replications of five plants

**Mean of two replications of five plants



Fig. 1. Nematode hatching pan.

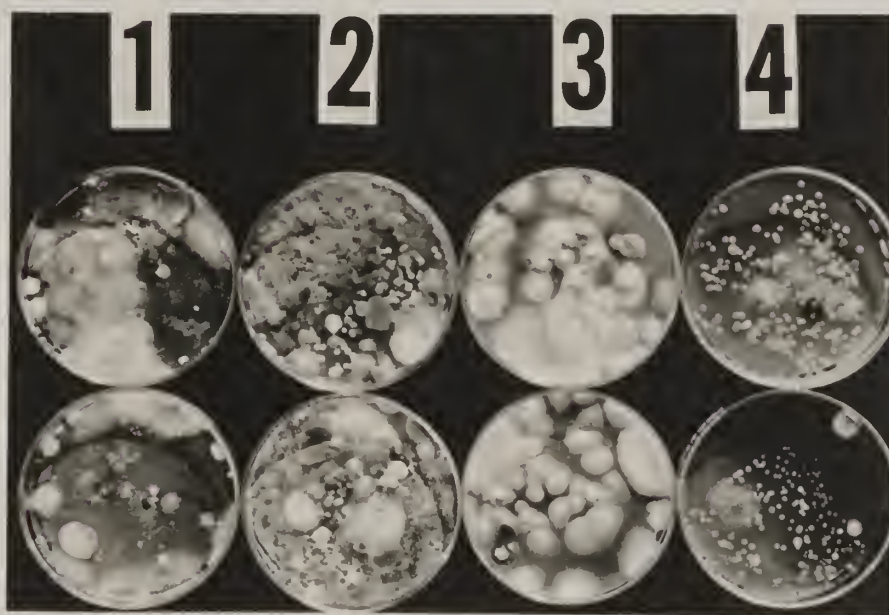


Fig. 2. Reduction in contamination due to treatment.

1. Root exudate solution.
2. Root exudate solution + additives (sterilants).
3. Zinc chloride solution.
4. Zinc chloride solution + additives.

Losses in infectivity of larvae for all treatments stored under refrigeration at the end of 4 wks. were small, Table I. This was also true for larvae stored at room temperature in the root exudate and zinc chloride treatments for the first 2 wks., but the infectivity of the larvae decreased for the 3rd and 4th wks. However, when the additive was included in the hatching solution, storage of the larvae at room temperature resulted in high losses in infectivity with each additional week. (Table I).

The difference in reduction of fungi and bacteria due to treatments is illustrated by Fig. 2. Preliminary results indicate the bactericides and fungicide are more effective when used with zinc chloride. In one experiment of 320 transplanted sugarbeets grown in sterilized sand, not a single beet died from root-rot during the 8 days between inoculation and harvest. In a similar experiment where plants were grown in sterile soil less than 1% of the 1400 plants inoculated died during a 4 wk. growing period.

The results of the sterility test showed that no fungi were found in any of the treatments of 24 hrs. or longer. However, the number of bacteria present diminished with length of time as shown in Table II. Similar subsequent tests of treatment up to 10 days did not eliminate the bacteria.

Infectivity trial results showed that although the variation in number of nematodes penetrating the root of each plant was great there was no difference due to treatment length, Table III.

Discussion:

These data show that sufficient larvae can be hatched and eliminated of all fungi and most bacteria to inoculate 500 to 1000 plants per wk. depending on the number of hatching pans used, condition of the eggs within the cysts, and the number of larvae used to inoculate each plant.

Although root exudate is superior to zinc chloride as a hatching agent during the initial period of hatching, the total hatch during a 4 wk. period in zinc chloride solution is about 80% of root exudate, (personal communication with Mr. A. E. Steele, Nematologist). This advantage of root exudate is not significant when the time and expense required to grow plants and collect exudate is considered. Also the advantage of obtaining larvae with fewer fungi and bacteria when hatched in zinc chloride plus the additive is of great importance.

The factor or factors responsible for the increase in number of larvae hatched when the additive is included in the hatching solution is not apparent.

Table II. Decrease in bacterial population with increased length of treatment of nematode larvae.

\bar{x} no. of bacterial colonies	Days of treatment after hatching					
	0	1	2	3	4	5
Test						
1	a	548	358	112	97	6
2	a	1889	315	297	66	40
^a Agar completely covered with bacteria and fungi						

Table III. Mean number of larvae infecting each plant with each additional day of treatment.

\bar{x} no. of larvae	Days of treatment after hatching					
	0	1	2	3	4	5
	29.0	39.8	44.6	34.8	33.8	35.6

Of real significant importance is the fact that the infectivity of hatched larvae is not reduced significantly due to treatment when refrigerated. Thus large populations of larvae can be accumulated over a period of time when extremely large numbers are required. Preliminary results of studies show that large quantities of full mature cysts can be obtained by inoculating sugarbeet plants with larvae grown in sterile sand.

Although the nematode larvae are not completely eliminated of all bacteria, we believe the treatment will provide larvae in sufficient quantities to be used as inoculum for large greenhouse studies where monoxenic conditions are not required.

To obtain nematodes of one species, cysts should be hand picked. Where this is not a requirement, most of the free living nematodes can be eliminated by using the hatching pan as an adaptation of the Baermann-funnel technique, thus eliminating those nematodes that appear in the water of the lower pie pan. This technique is particularly effective if the cysts used for hatching have been produced on plants grown in sand culture. Some loss of nematode larvae due to hatching does occur, however, water is a poor hatching agent and the loss is usually small. Following this treatment the water in the lower pan is replaced with hatching solution.

Literature cited:

1. Clark, A. M. and Audrey Shepherd. 1965. Zinc and other metallic ions as hatching agents for the beet cyst nematode. Heterodera schachtii Schm. Nature 208:502.
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INTERSPECIFIC HYBRIDIZATION^{1/}

VULGARES-PATELLARES HYBRIDS

Selection for resistance to sugarbeet nematode (Heterodera schachtii), was continued in the first and second backcross and in F₂ hybrids between sugarbeets and Patellares species.

The technique of soil infestation by nematode cysts was the same as in 1965. All plants selected were tested 3 times for resistance. Hybrids selected were separated into 2 groups. The first group consisted of plants having from 0 to 5 females on the roots; the second group consisted of plants with 5 to 10 females on the roots. All plants which had over 10 females were discarded.

Among b₁ hybrids some nematode resistant plants were selected and placed in the group 1. Since the technique of soil infestation was changed in 1965, and the infested soil contained more cysts, less variation in the grade of resistance was observed. More plants were severely infected and fewer plants appeared to be resistant. Therefore, the number of plants selected for nematode resistance decreased, but the chances of more reliable selection were increased.

Among 500 F₂ hybrids tested also some resistant plants were selected.

Selection in one b₂ progeny looked the most promising. A b₁ plant which had 19 chromosomes was selected for nematode resistance. This plant belonged to the group 1. Thirty offspring of the selected plant were tested for resistance in 1965. Of these, 18 plants were susceptible, having roots covered with hundreds of females, and 12 plants were highly resistant. Six of the highly resistant plants remained free of females in 3 tests, the other 6 plants had 1 to 3 females in one of 3 tests. The plants selected grew in the greenhouse in 1966 and were checked for chromosome number. All of the 12 resistant plants had 19 chromosomes. The group of susceptible plants differed from the group of resistant plants in morphological characteristics. The susceptible plants resembled sugarbeets; whereas plants in the resistant group developed long petioles and narrow, elongated leaves. They had the typical appearance of aneuploids with 19 chromosomes.

After 3 months of thermal induction, the resistant plants were taken to the greenhouse for seed production. Six plants developed seed stalks, flowered, and set some seed. The other 6 plants did not bolt, and were exposed to thermal induction again. Probably the low bolting tendency, as well as a comparatively low fertility, was caused by severe effects of virus yellow. Seed harvested from the resistant plants were planted and the seedlings transplanted into nematode-infested soil for test in the b₃ generation. For the first time the resistance to nematode was transferred to b₂ generation. Also, for the first time several highly resistant plants appeared in

^{1/} Investigations conducted by Helen Savitsky.

the progeny of a plant selected for resistance. Obviously the chromosome responsible for resistance was transferred to sugarbeets from Patellares species.

VULGARIS-COROLLIFLORA HYBRIDS

Species of the section Corollinae Tr. are immune, or highly resistant to curly top. Transmission of a high grade of resistance to curly top from these species to sugarbeets is of great practical importance.

Dr. V. F. Savitsky obtained a tetraploid hybrid between sugarbeet and B. corolliflora. The F_1 hybrid plant was pollinated by diploid sugarbeets in the greenhouse and b_1 seed obtained. The b_1 hybrids were tested by Dr. Bennett for curly top resistance. Dr. Bennett inoculated 400 b_1 plants with a virulent strain of curly top virus (Paso Robles) and selected 32 plants which did not show symptoms of disease. The plants selected were reinoculated with the same virus when in the 10- to 12-leaf stage. Twenty-nine plants of this group did not show symptoms of curly top and were selected as highly resistant hybrids.

A cytological study showed that all b_1 hybrids were triploids, or aneuploids approaching to triploids. The b_1 plants selected were pollinated in the greenhouse by sugarbeets, and b_2 seed were harvested. After the seed harvest, all b_1 plants were exposed to thermal induction and produced some seed in 1966. To induce translocations, 8 plants of this group were irradiated by X-rays in the Lawrence Radiation Laboratory of the University of California at Berkeley. The doses 1000r, 1500r, and 2000r were applied.

The b_2 seed, harvested from b_1 plants, were planted in greenhouse. In spite of a comparatively good fertility of b_1 hybrids, germination of b_2 seed was very poor. Of 11,764 seed planted, 169 seedlings were obtained. Some seedlings showed different abnormalities, such as an absence of a bud between cotyledons, leaves growing from the petioles, etc. Some seedlings were low in vitality and died. All b_2 plants that survived resembled sugarbeets more than did the b_1 hybrids, although they all maintained some resemblance to B. corolliflora. The b_2 hybrids differed very much in morphological traits from each other. Many were strong, vigorous plants; others were weak with narrow petioles and narrow leaf blades; some plants were dwarfs.

All b_2 hybrids survived were given to Dr. Bennett for the test for curly top resistance and selection of resistant plants in the b_2 generation. The hybrids were recently inoculated with the Paso Robles virus.

STUDIES ON POLYPLOIDY

FERTILIZATION AND FRUIT DEVELOPMENT IN DIPLOID, TRIPLOID AND TETRAPLOID

MATINGS IN SUGARBEETS.

A study of the viability of diploid, triploid and tetraploid seed has both a theoretical and practical value. There are some indications that triploid sugarbeet seed are less viable and lower in germination than the diploid seed. Investigations undertaken consist in a study of fruit development, seed germination, and cytological and embryological study. Several environment factors, as well as the grade of perfection of inflorescence in female plants, simultaneous flowering of both the component of hybridization etc. influence fertilization and seed development. But the main purpose of these investigations is to determine whether some genetic processes control the viability of seed at different ploidy levels. The first data on effectiveness of fertilization and fruit development in diploid, triploid, and tetraploid matings are reported here.

MATERIALS AND METHODS

Eight diploid monogerm male-sterile lines, SLC 502, F_1 -64-569-HS, F-61-562-HO, SLC 91, U.I. 129, A-61225, F_1 -A-61226, and A-63113 were pollinated by diploid and tetraploid monogerm and multigerm populations at 8 different isolations. The pollinators were (1) 2 diploid monogerm populations 4-568, and SLC 91, (2) 2 diploid multigerm populations 112 and US 401, (3) 2 tetraploid monogerm populations SLC 15, and Klein E, and (4) 2 tetraploid multigerm populations 4-601, and 4-900.

In all isolations, plants were well developed and seed setting was normal. To secure a sufficient pollination, the male-sterile lines and the pollinators were planted in alternating rows. All male-sterile lines were checked for male-sterility and did not contain pollen-fertile plants. The male-sterile lines bolted later than the pollinators and started to flower when pollinators were in full blossom. Pollinators produced abundant pollen providing for a successful pollination of male-sterile plants. Possibly the supply of pollen was limited to some extent for very late bolting plants.

A study of the effectiveness of fertilization and seed development in $2n$, $3n$ and $4n$ matings was based on examination of ovules. Ovules were examined in 5 plants of each male-sterile line in all matings and in 5 plants in each population pollinator. A total of 360 plants were examined. From each plant, 2 branches were collected. On each branch 50 fruits (100 fruits per plant) were examined. The cap of the fruit was removed and the ovary opened. The number of unfertilized, fertilized normal, and fertilized aborted ovules was determined per 100 monogerm and multigerm fruits. In monogerm beets, flowers with unfertilized ovules did not develop into fruits, but remained in the branches alternating with the developed fruits. At the time of examination of 100 fruits, ovules of such flowers were included in the category of

unfertilized ovules. The unfertilized ovules were little dark lumps lying on the bottom of the ovary. Fertilized normally developed ovules were large, covered with brown seed coat and well filled; when crushed, the embryo and starch could be seen. The fertilized aborted ovules were also comparatively large and covered with brown seed coat, but shriveled, thin, and empty when crushed.

EXPERIMENTAL RESULTS.

Fertilization and seed development in diploid and tetraploid populations. Open-pollinated diploid and tetraploid population-pollinators grown on different isolations produced $2n$ and $4n$ fruits. The different genetic nature of diploids and tetraploids caused some variations in the effectiveness of fertilization and in the mode of seed development.

The main difference between the diploid and tetraploid populations consisted in the amount of unfertilized ovules. Mean percent of unfertilized ovules (34.42) for both monogerm and multigerm tetraploids greatly exceeded their percent in diploid monogerm and multigerm populations (13.86) (Table 1). Analysis of variance indicated that the difference between $2n$ and $4n$ populations in percent of unfertilized ovules is highly significant. F equals 42.32 and F tabulated is (7.60) at the 1% level. There is no significant difference in this character between monogerm and multigerm beets, although percent of unfertilized ovules is higher in tetraploid multigerm than in tetraploid monogerm populations. The interaction ($2n$ vs. $4n$) \times (multi vs. mono) is also significant (Table 2).

The high percent of unfertilized ovules in tetraploids is obviously caused by the irregularities in meiosis and formation of inviable egg cells with the number of chromosomes considerably deviating from the diploid number.

Because of the lower number of viable egg cells, percent of fertilized normally developed ovules is lower in tetraploids (56.15) than in diploids (74.09) (Table 1). Difference between diploid and tetraploid populations in the percent of normal ovules is highly significant. F calculated (12.34) exceeds F tabulated at the 1% level (7.60) (Table 3). There is no significant difference between monogerm and multigerm populations in the percent of normally developed ovules. It should be noticed that monogerm diploids and tetraploids had almost the same percentage of normal ovules; whereas, in multigerm tetraploids the percent of normal ovules was lower than in monogerm tetraploid populations. In the multigerm beets, ovules per fruit outnumber the ovules per fruit in the monogerm beets; therefore, the number of normally developed ovules will be always higher in multigerm than in monogerm plants in spite of equal, or even higher percent of normally developed ovules in the monogerm plants.

Abortion of ovules is almost the same in tetraploids as in diploids. Percent of aborted ovules was even a little lower in tetraploid populations (9.43) in comparison with the diploid populations (12.05) (Table 1).

Table 1 ... Number and percent of unfertilized, fertilized normal and aborted ovules in diploid and tetraploid, monogerm and multigerm pollinators.

Ovules in 500 fruits per 5 plants in each population							
	Total number of ovules	Unfertilized		Fertilized			
		Number	Percent	Normal		Aborted	
				Number	Percent	Number	Percent
<u>2n Populations</u>							
4-568-m ₂	500	96	19.20	329	65.80	75	15.00
S.L.C.91-m ₂	500	95	19.00	340	68.00	65	13.00
112-M ₂	1420	152	10.10	1116	78.60	152	10.70
U.S. 401-M ₂	1266	168	13.27	946	74.72	152	12.01
Total	3686	511		2731		444	
Percent			13.86		74.09		12.05
<u>4n Populations</u>							
S.L.C.15-m ₄	500	136	27.20	316	63.20	48	9.60
Klein E-m ₄	500	135	27.00	326	65.20	39	7.80
4-601-M ₄	1320	492	37.27	746	56.52	82	6.21
4-900-M ₄	1338	496	37.07	666	49.78	176	13.15
Total	3658	1259		2054		345	
Percent			34.42		56.15		9.43

Table 2 ... Analysis of variance for unfertilized ovules in diploid and tetraploid, monogerm and multigerm pollinators.

Source of variation	Sum of squares	d.f.	Mean squares	Variance Ratio	F tabulated	
				F	.05	.01
Total sum of squares	27,850.2061	39	-	-	-	-
Crosses	130,059.2339	7	488.0780	7.70	2.35	3.33
2n vs. 4n	505,563.3421	1	2,682.8802	42.32	4.18	7.60
Multi vs. mono	452,261.9161	1	17,8089	< 1	4.18	7.60
(2n vs. 4n) x (Multi vs. mono)	259,981.3621	1	702.1518	11.08	4.18	7.60
Error		29	63.3917			

Table 3 ... Analysis of variance for fertilized normal ovules in diploid and tetraploid, monogerm and multigerm pollinators.

Source of variation	Sum of squares	d.f.	Mean squares	Variance Ratio	F tabular	
				F	.05	.01
Total sum of squares	177,092.8214	39	-	-	-	-
Crosses	866,174.5154	7	405.8630	3.05	2.35	3.33
2n vs. 4n	3,440,706.7138	1	1,641.4735	12.34	4.18	7.60
Multi vs. mono	3,407,941.0900	1	3.1923	<1	4.18	7.60
(2n vs. 4n) x (Multi vs. mono)	1,730,610.5338	1	1,022.5253	7.26	4.18	7.60
Error		29	133.0317			

Table 4... Analysis of variance for fertilized aborted ovules in diploid and tetraploid monogerm and multigerm pollinators.

Source of variation	Sum of squares	d.f.	Mean squares	Variance ratio	F tabulated	
				F	.05	.01
Total sum of squares	5,847.5064	39	-	-	-	-
Crosses	25,569.2566	7	43.5146	1.72	2.35	3.33
2n vs. 4n	98,731.1048	1	127.3062	5.03	4.18	7.60
Multi vs. mono	96,303.5600	1	5.9290	< 1	4.18	7.60
(2n vs. 4n) x (Multi vs. mono)	49,724.8248	1	29.9983	1.19	4.18	7.60
Error	-	29	25.2985	-	-	-

Difference is significant but at a small grade: F calculated 5.03 slightly exceeded F tabulated at the 5% level (4.18) (Table 4). There is no significant difference between monogerm and multigerm beets in percent of aborted ovules. Thus, lower fertility of tetraploid populations is due mainly to the sterility of gametes; not to the abortion of fertilized ovules.

Fertilization and seed development in male-sterile lines. The diploid monogerm male-sterile lines pollinated by $2n$ and $4n$ populations developed diploid and triploid fruits, respectively.

In the diploid fruits derived from pollination by monogerm and multigerm diploid populations, mean percent of unfertilized ovules was higher (23.69) than in the diploid pollinators themselves (13.86). In the triploid fruits, derived from pollination of male-sterile plants by tetraploid pollinators, mean percent of unfertilized ovules was still higher (28.08) (Table 5). Several factors influenced such a decline in the effectiveness of fertilization in different matings. Analysis of variance indicated that difference between matings was significant and the biggest difference was between $2n$ and $3n$ matings. F calculated is 31.78, while F tabulated at the 5% level is 3.89, and at the 1% level 6.76 (Table 6). There is no difference in the percent of unfertilized ovules between monogerm and multigerm crosses, but the interaction ($2n$ vs. $3n$) \times (multi vs. mono) is highly significant. F calculated equals 17.80 against F tabulated at 5% 3.89, and at 1% 6.76 (Table 6).

In male-sterile lines, pollinated by $4n$ monogerm populations ($3n$ fruits), percent of unfertilized ovules increased, in comparison with diploid matings, to 26.73 and 27.10. After pollination by the $4n$ multigerm populations, percent of unfertilized ovules was the highest 28.45 and 30.03 (Table 5). In other words, the effectiveness of fertilization was the lowest in matings in which tetraploid multigerm populations were used as pollinators.

There was also a significant difference between individual male-sterile lines. F is 7.75 against F tabulated at 5%, 2.05, and at 1%, 2.73. The lines F-61-562 and A-63113 had the highest percent of unfertilized ovules, and the lines A-61225 and A-61226 had the lowest (sum in all matings). Thus, the combined effect of different pollinators (diploid or tetraploid, monogerm or multigerm) and different responsiveness of the individual male-sterile lines influenced the effectiveness of fertilization in different matings.

Percent of fertilized and normally developed ovules was high in $2n$ fruits obtained from pollination of male-sterile lines by monogerm and multigerm populations (6231), although it was lower than in the $2n$ fruits of the open-pollinated diploid populations (74.09). In male-sterile lines pollinated by $4n$ populations ($3n$ fruits), percent of normally developed ovules declined to 54.36 (Table 5). Analysis of variance for percent of normal ovules showed significant differences between matings, between $2n$ and $3n$ fruits, and between fruits obtained from pollination by monogerm and multigerm populations. The difference was especially highly significant for the interaction ($2n$ vs. $3n$) \times (multi vs. mono). F calculated for this interaction equalled 53.27, and F tabulated was 3.84 at 5%, and 6.76 at 1%. Also highly significant was the difference in percent of normal ovules between $2n$ and

Table 5 ... Number and percent of unfertilized, fertilized normal and aborted ovules in 2n and 3n fruits in 8 male-sterile monogerm lines x by diploid and tetraploid monogerm and multigerm pollinators.

Matings	Ovules 4,000 per 8 male-sterile lines in a mating							
	Unfertilized		Fertilized				Aborted	
			Normal		Aborted		Normal+Aborted	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
<u>2n mono fruits</u>								
8 M.S.lines-m ₂ x 4-568-m ₂	1078	26.95	2430	60.75	492	12.30	2922	16.84
8 M.S.lines-m ₂ x S.L.C.91-m ₂	987	24.67	2421	60.53	592	14.80	3013	19.65
8 M.S.lines-m ₂ x 112-M ₂	909	22.73	2629	65.73	462	11.54	3091	14.95
8 M.S.lines-m ₂ x U.S.401-M ₂	817	20.42	2489	62.23	694	17.35	3183	21.80
Total (16,000 ovules) Percent	3791	23.69	9969	62.31	2240	14.00	12209	10.09
<u>3n mono-fruits</u>								
8 M.S.lines-m ₂ x S.L.C.15-m ₄	1084	27.10	2379	59.48	537	13.42	2916	18.07
8 M.S.lines-m ₂ x Klein E-m ₄	1069	26.73	2513	62.82	418	10.45	2931	14.26
8 M.S.lines-m ₂ x 4-601-M ₄	1201	30.03	1996	49.90	803	20.07	2799	28.69
8 M.S.lines-m ₂ x 4-900-M ₄	1138	28.45	1808	45.23	1053	26.30	2861	36.81
Total (16,000 ovules) Percent	4492	28.08	8697	54.36	2811	17.56	11508	24.43

Table 6... Analysis of variance for unfertilized ovules in 8 diploid male-sterile lines pollinated by diploid and tetraploid monogerm and multigerm populations.

Source of variation	Sum of squares	d.f.	Mean squares	Variance ratio F	F tabulated .05	F tabulated .01
Total sum of squares	236,593	319	-	-	-	-
Crosses	1,121,035	63	155.6623	3.22	1.42	1.62
Male-sterile lines	8,681,005	7	374.9781	7.75	2.05	2.73
Matings (male)	8,685,285	7	390.2638	8.07	2.05	2.73
Lines x matings	-	49	90.8169	1.88	1.42	1.62
2n vs. 3n	34,549,745	1	1,535.6281	31.78	3.89	6.76
Multi x mono	34,315,749	1	73.1531	1.51	3.89	6.76
(2n vs. 3n) x (Multi vs. mono)	17,349,631	1	861.3277	17.80	3.89	6.76
(2n vs. 3n) x lines	4,377,022	7	41.4781	<1	2.05	2.73
(Multi vs. mono) x lines	4,359,449	7	124.8817	2.58	2.05	2.73
Error		256	48.3828			

3n fruits. F was 41.24 against F tabulated 3.84 at 5%, and 6.76 at 1% (Table 7).

2n fruits obtained from pollination of male-sterile lines by monogerm and multigerm populations differed little in percent of normal ovules. Variation in different matings ranged from 60.53% to 65.73%. 3n fruits obtained from pollination by 4n monogerm populations were close in percent of normal ovules to 2n fruits (59.48 and 62.82). But pollination by 4n multigerm populations (3n fruits) decreased percent of normal ovules to 49.90 and 45.23 (Table 5).

The individual male-sterile lines differed significantly in percent of normal ovules. F was 5.51 against F tabulated, 2.01 (5%) and 2.7 (1%) (Table 7). The lines A-61225, A-61226, and SLC 502 had the highest percent and the lines F-61-562 and A-63113 the lowest percent of normal ovules (sum from all matings). As already mentioned the same male-sterile lines differed in the lowest and the highest percent of unfertilized ovules. A direct negative correlation was observed: the higher percent of unfertilized ovules, the lower the percent of normal ovules, and vice versa. In the individual lines, percent of normal ovules in 2n fruits varied from 45.60 to 74.60 in 2n MS x m₂ crosses, and from 63.00 to 74.80 in 2n MS x M₂ crosses. In 3n fruits, percent of normally developed ovules in the individual lines varied from 55.00 to 71.80 in 2n MS x m₄ crosses, and from 27.80 to 55.40 in M₄ crosses (Tables 8, 9, 10, 11).

In all matings some fertilized ovules were aborted. In 2n fruits obtained from pollination of male-sterile lines by the diploid monogerm and multigerm populations, mean percent of aborted ovules was not high (14.00). In 3n fruits, obtained from pollination by monogerm tetraploids, percent of aborted ovules was practically the same as in 2n fruits, 10.45 and 13.42 in 2 matings. But when male-sterile lines were pollinated by 4n multigerm populations, percent of aborted ovules increased in 2 crosses to 20.07 and 26.30. Mean percent of aborted ovules for all kind of 3n fruits was 17.56 (Table 5).

Analysis of variance for aborted ovules indicated significant difference between matings, between 2n vs. 3n fruits and between other processes resulting from hybridization. The biggest significant difference was observed between multi vs. mono, for which F was 52.31 against F tabulated 3.84 at 5%, and 6.76 at 1% level. Also for the interaction (2n vs. 3n) x (multi vs. mono) the difference was highly significant. F calculated for this interaction equalled 37.97 and F tabulated was 3.84 at the 5% and 6.76 at 1% level. 2n fruits differed significantly in percent of aborted ovules from 3n fruits; F calculated was 18.02 against F tabulated 3.84 at the 5% level, and 6.76 at the 1% level (Table 12). When 2n fruits were compared with 3n fruits derived from crosses with monogerm tetraploids only, the difference in percent of aborted ovules between 2n and 3n fruits was insignificant. F calculated was 2.53 and F tabulated was 3.92 at the 5% level (Table 13).

A significant difference between individual male-sterile lines was not as high as the differences mentioned above. F calculated for lines was 4.73, while F tabulated was 2.01 at the 5% and 2.7 at the 1% level. Male-sterile lines SLC 502, A-61226 and A-63113 had the lowest and the lines U.I. 129 and SLC 91 had the highest percent of aborted ovules (sum from all matings). In the individual lines, percent of aborted ovules varied in 2n fruits from 7.20 to 30.20 in 2n MS x m_2 crosses, and from 3.00 to 24.80 in 2n MS x M_2 crosses. In the 3n fruits, percent of aborted ovules varied in the individual lines from 6.00 to 19.20 in 2n MS x m_4 crosses, and from 16.20 to 35.40 in 2n MS x M_4 crosses (Tables 8, 9, 10, 11).

Seed harvested from monogerm male-sterile lines consists of fruits with normal and aborted ovules only. Flowers with unfertilized ovules do not develop into fruits and are lost. Mean percent of aborted ovules in the 2n seed harvested, which were derived from pollination by monogerm and multigerm diploid populations, was 10.09. 3n seed, derived from pollination of male-sterile lines by monogerm tetraploids had 14.26 and 18.07 percent of aborted ovules. These figures are in the limit of variation in the 2n seed. 3n seed, derived from crosses with multigerm tetraploids, had higher percent of aborted ovules, 28.69 and 36.81. The augmentation was caused by multigerm pollinators. The pollinator 4-900 gave especially high percent of aborted ovules (Table 5).

CONCLUSION

1. Tetraploid open-pollinated populations differ from the diploid open-pollinated populations by a higher percent of unfertilized ovules, which is obviously due to the irregularities in meiosis and formation of inviable egg cells. The tetraploid populations did not exceed in this experiment the diploid populations in percent of aborted ovules.

2. The tetraploid multigerm populations differ from tetraploid monogerm populations by a higher percent of unfertilized ovules, and consequently by a lower percent of normally developed ovules.

3. Abortion of fertilized ovules that causes the inviability of seed was observed in diploid, triploid, and tetraploid fruits.

4. Diploid fruits derived from pollination of 2n male-sterile lines by 2n monogerm and multigerm populations, and triploid fruits obtained from pollination by 4n monogerm populations, did not differ in percent of aborted ovules.

5. Triploid fruits obtained from pollination of 2n male-sterile lines by multigerm tetraploid populations differed significantly from the diploid fruits in percent of aborted ovules. Data obtained give an important indication that the multigerm tetraploid populations used as pollinators for diploid male-sterile lines increase ovule abortion and lower the viability of 3n fruits. But, before the final conclusion may be drawn, more crosses

with multigerm tetraploids should be examined and the data for seed germination obtained. A cytological study should reveal the causes of this appearance.

6. Effectiveness of fertilization and the grade of ovule abortion is controlled, as shown by the analysis of variance, by both male and female parents. But the influence of pollinators was much more important in this experiment than that of male-sterile lines. The value of variance ratio (F) in significant differences is much higher for the processes caused by pollinators than the value of F for the differences caused by male-sterile lines.

7. To avoid possible variations caused by a year, or location, this study will be continued next year with a broader selection of material.

Table 7... Analysis of variance for fertilized normal ovules in 8 diploid male-sterile lines pollinated by diploid and tetraploid monogerm and multigerm populations.

Source of variation	Sum of squares	d.f.	Mean squares	Variance ratio F	F tabulated .05	F tabulated .01
Total sum of squares	1,144,603	319	-	-	-	-
Crosses	5,576,950	63	416.3313	3.65	1.32	1.3
Male-sterile lines	43,742,508	7	628.8389	5.51	2.01	2.70
Matings (male)	44,104,210	7	1,920.533	16.83	2.01	2.7
Lines x matings	-	49	171.084	1.50	1.45	1.65
2n vs. 3n	175,018,770	1	4,706.182	41.24	3.84	6.70
Multi vs. mono	174,545,978	1	1,751.232	15.35	3.84	6.7
2n vs. 3n) x (Multi vs. mono)	88,135,814	1	6,079.133	53.27	3.84	6.7
(2n vs. 3n) x lines	21,982,886	7	125.0168	1.09	2.01	2.70
(Multi vs. mono) x lines	21,919,568	7	94.8383	0.83	2.01	2.70
Error	-	256	114.113	-	-	-

Table 8 ... Percent of unfertilized, fertilized normal and aborted ovules in 8 diploid male-sterile monogerm lines pollinated by diploid monogerm populations.

M.S. lines - m_2 x 4-568- m_2				M.S. lines m_2 x S.L.C. 91- m_2			
Ovules 500 per 5 plants in a line				Ovules 500 per 5 plants in a line			
Male-sterile lines	Fertilized			Male-sterile lines	Fertilized		
	Unfertilized	Normal	Aborted		Unfertilized	Normal	Aborted
	Percent	Percent	Percent		Percent	Percent	Percent
S.L.C. 502	30.40	62.00	7.60	S.L.C. 502	22.20	64.40	13.40
F ₁ 64-569 H3	21.60	70.00	8.40	F ₁ 64-569 H3	23.60	46.20	30.20
F-61-562 H0	33.60	50.00	16.40	F-61-562 H0	43.00	45.60	11.40
S.L.C. 91	19.20	65.00	15.80	S.L.C. 91	19.60	63.80	16.60
U.I. 129	29.29	49.60	21.20	U.I. 129	19.00	71.00	10.00
A-61225	25.20	61.80	13.00	A-61225	17.00	74.60	8.40
F ₁ A-61226	26.00	66.80	7.20	F ₁ A-61226	20.60	62.00	17.40
A-63113	30.40	60.80	8.80	A-63113	32.40	56.60	11.00

Table 9 ... Percent of unfertilized, fertilized normal and aborted ovules in 8 diploid male-sterile monogerm lines pollinated by diploid multigerm populations.

M.S. lines - m ₂ x 112-M ₂				M.S. lines - m ₂ x U.S. 401 - M ₂			
Ovules 500 per 5 plants in a line				Ovules 500 per 5 plants in a line			
Male-sterile lines	Fertilized		Male-sterile lines	Fertilized		Male-sterile lines	Fertilized
	Unfertilized	Percent		Unfertilized	Percent		
	Percent			Percent			Percent
S.L.C. 502	23.40	73.60	3.00	S.L.C. 502	21.60	64.00	14.40
F ₁ 64-569 H3	21.00	66.60	12.40	F ₁ 64-569 H3	19.40	65.20	15.40
F-61-562 H0	24.00	59.80	16.20	F-61-562 H0	22.80	55.60	21.60
S.L.C. 91	23.60	63.00	13.40	S.L.C. 91	22.80	63.20	14.00
U.I. 129	25.20	63.00	11.80	U.I. 129	17.40	57.80	24.80
A-61225	21.80	67.20	11.00	A-61225	21.40	68.20	10.40
F ₁ A-61226	15.80	74.80	9.40	F ₁ A-61226	18.00	66.40	15.60
A-63113	27.00	57.80	15.20	A-63113	20.00	57.40	22.60

Table 10.... Percent of unfertilized, fertilized normal and aborted ovules in 8 diploid male-sterile monogerm lines pollinated by tetraploid monogerm pollinators.

M.S. lines - m ₂ x S.L.C.15 - m ₄				M.S. lines m ₂ x Klein E - m ₄			
Male-sterile lines		Ovules 500 per 5 plants in a line		Male-sterile lines		Ovules 500 per 5 plants in a line	
		Fertilized				Fertilized	
		Unfertilized	Percent			Unfertilized	Percent
S.L.C. 502		26.20	64.20	S.L.C. 502		29.00	68.20
F ₁ - 64-569 H3		28.00	59.60	F ₁ -64-569 H3		26.80	65.40
F-61-562 H0		28.60	60.20	F-61-526 H0		27.20	62.60
S.L.C. 91		29.00	55.60	S.L.C. 91		28.20	58.00
U.I. 129		26.40	55.00	U.I. 129		23.20	57.60
A-61225		23.00	58.40	A-61225		18.40	71.80
F ₁ A-61226		24.00	65.40	F ₁ -A-61226		28.00	64.00
A-63113		31.60	57.40	A-63113		39.00	55.00
							6.00

Table 11.... Percent of unfertilized, fertilized normal and aborted ovules in 8 diploid male-sterile monogerm lines pollinated by tetraploid multigerm pollinators

M.S. lines - m ₂ x 4-601 - M ₄				M.S. lines - m ₂ x 4-900 - M ₄			
Ovules 500 per 5 plants in a line				Ovules 500 per 5 plants in a line			
Male-sterile lines	Male-sterile lines			Male-sterile lines	Male-sterile lines		
	Fertilized		Unfertilized		Fertilized		Unfertilized
	Percent	Normal Aborted			Percent	Normal Aborted	
Percent				Percent			
S.L.C. 502	31.80	52.00	16.20	S.L.C. 502	30.60	47.00	22.40
F ₁ -64-569 H3	40.00	36.80	23.20	F ₁ 64-569 H3	24.20	46.20	29.60
F-61-562-H0	31.40	49.80	18.80	F-61-562-H3	36.80	27.80	35.40
S.L.C. 91	28.20	52.60	19.20	S.L.C. 91	22.60	52.80	24.60
U.I. 129	24.60	49.20	26.20	U.I. 129	28.60	43.60	27.80
A-61225	28.40	49.20	22.40	A-61225	29.00	47.40	23.60
F ₁ A-61226	26.60	55.40	18.00	F ₁ A-61226	24.80	52.20	23.00
A-63113	29.20	54.20	16.60	A-63113	31.00	44.80	24.20

Table 12... Analysis of variance for fertilized aborted ovules in 8 diploid male-sterile lines pollinated by diploid and tetraploid monogerm and multigerm populations.

Source of variance	Sum of squares	d.f.	Mean squares	Variance ratio	F tabulated	
				F	.05	.01
Total sum of squares	108,365	319	-	-	-	-
Crosses	469,433	63	224.7575	3.97	1.32	1.30
Male-sterile lines	3,263,915	7	267.2853	4.73	2.01	2.70
Matings (male)	3,504,319	7	1,125.871	19.91	2.01	2.70
Lines x matings	-	49	89.95	1.59	1.45	1.65
2n vs. 3n	12,919,321	1	1,018.8781	18.02	3.84	6.76
Multi vs. mono	13,229,665	1	2,958.5281	52.31	3.84	6.76
(2n vs. 3n) x (Multi vs. mono)	6,868,153	1	2,147.6282	37.97	3.84	6.76
(2n vs. 3n) x lines	1,677,121	7	177.0424	3.13	2.01	2.70
(Multi vs. mono) x lines	1,703,435	7	87.9067	1.55	2.01	2.70
Error	-	256	56.556	-	-	-

Table 13... Analysis of variance for 2n and 3n fruits in 8 male-sterile lines pollinated by 2n monogerm and multigerm and by 4n monogerm populations.

Source of variance	Sum of squares	d.f.	Mean squares	Variance ratio F	F calculate .05
Total sum of squares	35,347	159	-	-	-
Crosses	150,433	31	-	-	-
2n vs. 3n	2,087,081	1	104,007	2.53	3.92
Error	-	128	41.0969	-	-

P A R T III

Progress reports of research conducted at
Crops Research Laboratory, Utah State University, Logan, Utah
by the
Staff of Sugarbeet Investigations, ARS-USDA
in cooperation with:

Utah Agricultural Experiment Station
and
Beet Sugar Development Foundation,
Fort Collins, Colorado

Research was conducted by:

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CURLY-TOP SCREENING TEST, THATCHER, UTAH

Albert M. Murphy

Introduction

In 1966, the curly-top screening work was expanded from approximately six acres in 1965, to 16 acres, more or less, in 1966. Expansion of the curly top nursery was primarily for the purpose of accomodating additional material furnished by the sugar companies, primarily The Holly Sugar Corporation for which they provided additional funds.

The method used to develop the curly top artificially in the curly-top nursery was similar to the method described in the Sugarbeet Research 1965 Report and in earlier publications.

The spring and early summer of 1966 can go down in history as the most adverse as far as weather was concerned in most of the inter-mountain beet growing territories. Well established agronomic practices of getting the sugarbeet crop off to a good start failed in numerous cases as nature did not cooperate. Extreme variations in temperature and drying winds caused the loss of original stands, making replanting necessary in many instances in all territories.

Some conditions such as temperatures low enough to kill emerging beet seedlings do not, for example, especially hurt the beet leafhopper. On the other hand, the sudden switch to high temperatures is extremely hard on sugarbeet seedlings, but is relatively favorable for the development of the beet leafhopper.

Since the ingredients for the artificial creation of the curly-top epidemic in the beet breeding field are well-known, it was not surprising to the writer that sooner or later in the course of time, these factors would be synchronized under natural conditions to the point where damage by curly top would indeed be alarming. 1966 proved to be that year. It is fantastic that the combinations of certain factors will put a specific beet field under such stress that it literally creates a vacuum in which curly top takes over and puts on a performance equal to the havoc displayed a quarter of a century ago.

Actually, the curly-top damage did not cause a great reduction in yield over an entire factory district. However, it certainly caused serious losses to individual growers who, through no fault of their own, set up an ideal situation for a curly-top epidemic. For example, probably the most serious damage was a field inspected near Pasco, Washington, in early September, which yielded 32 tons per acre in 1964, and was estimated to yield five tons per acre in 1966.

Curly-Top Screening Test, Thatcher, Utah

In the Bear River Valley of Utah where the curly-top nursery was located (Thatcher), it was determined by survey that the leafhopper population was very low in the local breeding area which normally contributes leafhoppers to the cultivated area. The writer, therefore, worked closely with Dr. George F. Knowlton, Utah Extension Entomologist, who was following the migration of the beet leafhopper from the southern breeding toward the north. On May 4, on a survey, Dr. Knowlton and the writer determined that the first leafhopper of the migration had reached as far north as Elberta, Utah (the area west of Utah Lake).

On June 7, the writer found the first curly-top symptoms in the susceptible variety, Old Type, which had been planted April 27. Several beet leafhoppers were noted, but were by no means numerous.

Results and Conclusions

Because the test beets were very small at approximately the time the beet leafhopper entered the field and because of the extremely high temperatures which developed following a most unfavorable spring, the test material was put under great stress and only the most resistant sorts survived the season. One very interesting observation was made that none of the nearby commercial beet fields had more than two or three percent curly top because they were planted at the normal time and were lucky in escaping the hazards of a most unfavorable spring. However, as mentioned earlier, in any beet-growing area where curly top is a potential threat, growers who unwittingly followed the requirements of obtaining a curly-top exposure indeed suffered great damage just like the curly-top nursery at Thatcher.

Curly-top information obtained for all sugarbeet breeders was sent to them. In addition to obtaining curly-top information on varieties, selections were made from varieties in which there was some hope that they would produce seed. In fact, the curly-top exposure was so drastic that it was not a matter of separating the men from the boys, but rather, the giants from the men.

Two especially important people visited the curly-top nursery in 1966: (1) Gordon E. Russell, Plant Breeding Institute of Cambridge, England, and (2) Dr. H. Rex Thomas, Director, Crops Research Division. Both were impressed.

Variety Tests, Logan, Utah, 1966

by George K. Ryser, J. C. Theurer, and Myron Stout

SOIL TYPES: Silt loam on North Farm, a silt clay loam on the South Farm, and a sandy loam on the Farmington Farm

PREVIOUS CROPS: North Farm - 1963 to 1965 fallowed with a few beets on part in 1963; South Farm - 1965, safflower, in 1964 and 1963 alfalfa; Farmington Farm - 1965, tomatoes, 1964, peas.

FERTILIZER: All fields had approximately 300 pounds/acre, 16-20-0 harrowed in before planting. South Farm obtained an additional side dressing of ammonium sulfate of 200 pounds/acre applied June 30. Farmington Farm also received a side dressing of 200 pounds ammonium sulfate, applied June 27, 1966.

PLANTING DATES: North Farm - May 2-3, 1966; South Farm - May 3, 1966; Farmington - April 5, 1966

THINNING DATES: North Farm - June 6-7, 1966; South Farm - June 13, 1966; Farmington - May 17, 1966

IRRIGATIONS: North Farm sprinkled after planting, before and after thinning, and on a weekly schedule from June 20, 1966 until two weeks prior to harvest. South Farm and Farmington furrow irrigations approximately on a weekly schedule after thinning--some deviation due to watering schedules

CURLY TOP: Light symptoms were noted at all farms

HARVESTED: North Farm - October 10-14, 1966; South Farm - October 17-18, 1966; Farmington Farm - November 3-4, 1966

Tops were removed with a roto-beater and scalped with tractor-mounted scalping tools, supplemented by long-handled hoe trimming to assure a complete topping job. Beets in each row of each plot were counted as they were thrown into the weighing basket after lifting with the harvester. Ten beet samples were obtained at random from each row of the two-row plots for sugar analysis and all beets in the plot were weighed to determine root yield.

Experimental Design.--All plots were two rows wide, except Test 4 which was planted with an alternate row of the same variety throughout the test, 22 inches apart, with a harvested plot length of 35 feet. Tests 1 and 5 were planted as balanced lattice with 8 and 6 replications, respectfully. Test 2 was a split plot randomized block with 8 replications and 30 entries. Test 3 and 4 were randomized blocks, 4 replications with 17 and 25 treatments, respectively.

TEST 1

Variety Test 1 was set up to evaluate the performance of 46 double cross restorer hybrids. Each entry consisted of a (CMS X Type-0) single cross pollinated by one of six (CMS X R_f) lines. Three additional varieties were used as checks in the test: 1114, a high yielding hybrid in past years' trials; a commercial variety from Amalgamated Sugar Company; and a commercial from Utah-Idaho Sugar Company.

Table 1 shows the results with entries listed in descending order of gross sugar per acre. The check variety, 1114, led all other entries for gross sugar. Significant differences were observed but not between the top 17 varieties for this character. As noted in previous years, Ovana lines, (308, Ov. 1, Ov. 3), and 3611 crossed to some of the best local material. (SLC 128, SLC 129, and CT 9), gave the highest yields. East Lansing inbred, EL 31, Amalgamated Sugar Company, AI-1, and 00.5, a derivative from an American Crystal Sugar Company line, were also parents in the better yielding hybrids.

Lines with 3611 (see 1965 Research Report) again showed the best sugar percentage, with entry 11, [(129 X 3611) X (CT 9 X R_f)], producing 15.87% and entry 41, [(AI-1 X 3611) X (C515 X R_f)], producing 15.74%. These were not significantly different from the first 13 entries ranked according to sugar percentage. All six male combinations were among the highest 13 entries. The range in sugar percentage was 2.21% with all three checks being near the mean of the test. The lowest sugar was produced by entry 8, [(308 X 00.5) X (CT 9 X R_f)]. All combinations with (308 X 00.5) as a female were significantly lower in sugar percent.

Entry 4, [(308 X 00.5) X (503 X R_f)], was significantly the poorest variety quality-wise. Entry 16, [(AI-1 X 503) X (128 X R_f)], had the lowest impurity index but was not significantly better than 19 other hybrids.

Three restorer hybrids were significantly better in gross sugar; four were significantly better in tons per acre; and one was significantly better than the best commercial check variety.

Significant differences were observed for the average performance of the six single cross restorer pollinators (Table 2). Hybrids with (SLC 128 X R_f) and (SLC 129 X R_f) pollinators had the highest gross sugar. The average yield of (C515 X R_f) hybrids was lower than the average of the five other groups. (FC 503 X R_f) and (SLC 128 X R_f) pollinators averaged 15.2%, the highest sucrose percentage. Hybrids with the (FC 503 X R_f) pollinator also were the poorest in quality as measured by the impurity index.

Table 2. RESTORER HYBRIDS, VARIETY TEST 1, NORTH FARM, LOGAN, UTAH, 1966
Means of Six Restorer Pollinators

Male parent	No. crosses	Gross sugar	T/A	Sucrose	Index
FC 503 X R _f	5	6641	22.70	15.2	436.7
CT 9 X R _f	8	6935	23.27	14.9	392.9
128 X R _f	5	7054	23.27	15.2	395.6
129 X R _f	9	7075	23.72	14.9	409.8
C515 X R _f	14	6541	21.61	15.1	403.9
AI-1 X R _f	5	6611	22.29	14.8	400.4
Mean	8	6826	22.81	15.0	405.4
Calculated F Value		5.50**	7.72	4.05**	3.76**

Table 1. VARIETY TEST 1, LOGAN, UTAH, 1966

49 Varieties		Balanced Lattice									
Variety code	Description	Acre yield		Percent sugar	Impurity index	PPM				Av. Beets per plot	
		Gross sugar	Tons beets			Amino N	Na	K			
01	1114 Check	7810	26.01	15.02	361	185	96	1288	79		
17	(308 X 3611) X 128	7764	25.10	15.50	475	246	114	1770	77		
28	(308 X 09A) X 129	7655	26.10	14.68	442	219	134	1508	80		
27	(CT 9 X Ov. 3) X 129	7435	24.93	14.89	408	179	142	1486	72		
15	(308 X 00.5) X 128	7359	25.52	14.37	475	202	161	1687	71		
20	(AI-1 X EL 31) X 129	7334	24.09	15.27	380	210	121	1297	81		
02	(129 X Ov. 1) X 503	7282	23.61	15.47	358	191	101	1313	73		
25	(AI-1 X 672) X 129	7280	24.17	15.07	435	207	116	1600	75		
19	(CT 9 X EL 32) X 128	7206	23.87	15.01	354	147	130	1410	73		
26	(308 X EL 31) X 129	7176	24.50	14.66	446	205	138	1582	74		
08	(308 X 00.5) X CT 9	7152	26.11	13.66	467	160	176	1610	75		
29	(AI-1 X 129) X 515	7098	23.06	15.34	367	165	122	1408	79		
03	(308 X 00.5) X 503	7087	22.63	15.67	341	160	97	1328	75		
10	(308 X 503) X CT 9	7042	22.87	15.35	343	148	91	1373	72		
46	(S3317 X Ov. 3) X AI-1	7007	23.11	15.19	394	214	115	1355	68		
13	(128 X Ov. 3) X CT 9	6995	23.76	14.72	403	190	129	1424	71		
14	(AI-1 X Ov. 3) X CT 9	6978	23.24	15.02	434	221	143	1496	71		
09	(308 X 129) X CT 9	6956	23.51	14.82	415	192	107	1542	75		
12	(308 X CT 5B) X CT 9	6951	23.13	14.99	350	170	95	1283	72		
23	(AI-1 X Ov. 3) X 129	6883	22.44	15.34	356	193	128	1223	68		
41	(AI-1 X 3611) X C515	6839	21.75	15.74	410	232	118	1460	75		
30	(502 X CT 9A) X C515	6819	21.70	15.68	346	180	101	1303	79		
07	(129 X Ov. 1) X CT 9	6801	22.98	14.77	380	172	102	1410	67		

(Continued on next page)

Table 1. Variety Test 1, Logan, Utah, 1966 (Continued from page 137) Page 2

Variety code	Description	Acre yield		Percent sugar	Impurity index	PPM			Av. Beets per plot
		Gross sugar	Tons beets			Amino N	Na	K	
22	(308 X CT5B) X 129	6800	23.49	14.41	403	168	120	1477	72
31	(308 X 00.5) X 515	6780	23.55	14.43	477	203	166	1687	71
16	(AI-1 X 503) X 128	6739	22.05	15.29	336	150	100	1306	71
21	(502 X 00.5) X 129	6728	22.05	15.24	406	170	130	1591	72
47	(502 X EL 32) X AI-1	6674	22.17	15.07	350	169	122	1250	78
38	(128 X 672) X 515	6673	21.76	15.36	419	235	131	1429	78
04	(308 X 00.5) X 503	6646	23.54	14.16	562	231	169	1985	74
11	(129 X 3611) X CT 9	6602	20.59	15.87	351	145	96	1467	64
48	U-I Commercial	6598	22.24	14.85	441	254	137	1385	73
39	(CT 9 X EL 31) X 515	6569	21.69	15.17	380	190	145	1332	80
43	(308 X 00.5) X AI-1	6564	22.02	14.93	364	168	127	1304	73
36	(CT 9 X 503) X 515	6556	21.94	15.05	398	168	112	1524	74
49	Amalgamated Comm.	6539	21.51	15.16	386	188	106	1430	76
40	(308 X EL 31) X 515	6512	22.17	14.69	458	236	156	1512	69
45	(NB 1 X Ov. 3) X AI-1	6510	21.88	14.89	401	175	143	1463	67
42	(S3317 X Ov. 1) X 515	6509	21.35	15.28	356	178	112	1313	72
35	(AI-1 X 503) X 515	6390	20.53	15.55	369	189	114	1394	74
24	(AI-1 X 503) X 129	6388	21.67	14.62	412	206	135	1378	71
34	(AI-1 X Ov. 3) 515	6382	20.89	15.23	428	245	137	1430	68
37	(CT 9 X EL 32) X 515	6353	21.29	14.91	414	201	149	1426	76
44	(308 X 00.5) X AI-1	6299	22.30	14.12	493	220	149	1683	56
06	(AI-1 X Ov. 1) X 503	6260	20.08	15.58	436	263	119	1475	72
33	(308 X 129) X 515	6231	21.21	14.68	406	173	152	1470	72
18	(502 X CT 5A) X 128	6203	19.81	15.62	338	174	89	1281	73
05	(502 X 00.5) X 503	5929	20.31	14.58	490	216	138	1772	65
32	(502 X 00.5) X 515	5861	19.63	14.93	429	175	114	1675	72
	Mean	6800	22.70	15.00	450	193	125	1461	73
	S. E. of Mean	295	0.96	0.19	19.2	17.6	10.7	49.7	2.7
	Sig. Diff. 5%	833	2.71	0.54	54	50	30	140	8
	C. V.	12.26	12.04	3.57	13.40	25.81	24.11	9.60	10.52
	Calculated F (Adj.)	2.20	2.81	5.76	6.67	2.83	4.08	9.98	2.89

Test 2

The purpose of Test 2 was to compare the performance of restorer and non-restorer hybrids from the same inbred lines. A split plot, randomized block design was used with main plots of 15 CMS hybrids and sub-plots of two pollinators, (129+a X R_f) and (129 CMS X R_f). The sub-plot was two rows wide, the whole plot four, planted in 22 inch rows, 35 feet long.

A ten beet sample was taken from each row of each plot for sugar and impurity analysis. Percent sugar was determined by use of a saccharimeter, amino N, Na, and K by the use of a spectrophotometer, gross sugar, tons per acre, and impurity index were calculated.

Females (whole plots) were significantly different from each other for gross sugar, tons per acre, sucrose percent, and impurity index at the North Farm (Table 1). There was no difference between the average performance of the pollinators for these measurements with the exception of the impurity index. Individual impurity measurements, however, were highly significant for both females and males (Table 1A). Comparison of individual females crossed to the two pollinators showed differences in amino N, Na, and impurity index, but not in the other characters.

At the South Farm significant differences for both males and females were observed for gross sugar, tonnage, sucrose percent, and impurity index, with exception of the latter two measurements for males (Table 2). The mean performance of the females for K was also different (Table 2A). CMS-R_f (cytoplasmic male sterile X restorer) hybrids with the same female generally had higher tonnage and less sucrose percent than counterpart +a-R_f (Mendelian male sterile X restorer) hybrids with the identical female parent.

Males, females, and the interaction of males X females, showed significance with the exception of males for tonnage in the Farmington test (Tables 3, 3A). The top producer and significantly so, was the CT 9 X EL 31 female crossed with +a-R_f male.

The performance of the 30 hybrids when locations are combined, and the combined analysis of variance are shown in Tables 4 and 4A. Highly significant differences were noted for locations for every character measured. At Farmington, hybrids averaged 10,983 pounds of gross sugar, while at the North and South Farms, near Logan, the averages were respectively 6,742 and 5,472 pounds. Beet weight showed a similar relationship of 37.8, 22.7, and 18.0 tons per acre. This result could very well be attributed to the fact that the Farmington test had six weeks longer growing season. Sucrose percent for the South Farm was 15.2%, for the North Farm 14.8%, and for Farmington 14.6%. The impurity index, amino N, Na, and K showed similar effects in that the South Farm was lowest and Farmington highest in impurity factors.

Female performance for all measurements was highly significant as indicated by the Analysis of Variance, Tables 4 and 4A. The two pollinators on the other hand failed to show differences in gross sugar and tons per acre yield.

Females performed differently at the three locations for gross sugar and tonnage, while males showed location interaction significance for every measurement except percent sucrose (Tables 4, 4A, and 5).

The most interesting comparison in this variety trial is the performance of restorer versus non-restorer pollinators. A summary of comparisons between the two pollinators is given in Table 5. The gross sugar for CMS-R_f was greater than that for +a-R_f at the North Farm, while at Farmington, it was vice versa. Averaged over the three locations there was no significant difference. CMS-R_f had greater tonnage at the North Farm, but there was no significance in the combined averages of the three locations. At Farmington, sucrose percent for the +a-R_f was significantly higher than for CMS X R_f, and accounted for significance in the average of the three locations for this character. Significant differences were consistently noted at two locations, the North Farm and Farmington, but not at the South Farm for impurity measurements. The CMS-R_f pollinator had the lowest impurity index and was lower in N and K, and higher in Na than the +a-R_f male.

This test is being repeated in 1967 to acquire another year's data regarding possible differences between restorer and non-restorer hybrids in sugarbeets.

Table 1. PERFORMANCE OF CMS-RESTORER VERSUS MENDELIAN-RESTORER HYBRIDS TEST 2, NORTH FARM, LOGAN, UTAH, 1966
8 & 16 Replications Respectively

Code		Gross sugar			Tons per acre			Percent sucrose			Index		
No.	Description	+	CMS	Mean	+	CMS	Mean	+	CMS	Mean	+	CMS	Mean
14	AI-1 X Ov. 3	7,087	7,342	7,215	23.41	24.28	23.84	15.06	15.01	15.04	407.5	356.6	382.1
06	AI-1 X CT 5B	6,954	7,072	7,013	23.30	23.45	23.38	14.93	15.05	14.99	425.8	370.5	398.1
01	AI-1 X C672	6,719	7,280	7,000	23.07	25.14	24.11	14.55	14.48	14.51	475.8	450.0	467.9
10	AI-1 X FC 503	6,523	6,395	6,459	22.16	21.79	21.98	14.66	14.66	14.66	407.5	423.1	415.3
12	AI-1 X Line 289	6,389	6,535	6,462	21.00	21.11	21.06	15.16	15.46	15.31	437.0	444.3	441.6
09	AI-1 X EL 31	6,359	6,287	6,323	21.31	21.13	21.22	14.94	14.90	14.92	472.1	415.3	443.7
04	308 X EL 31	7,217	6,738	6,977	24.93	23.35	24.14	14.46	14.41	14.43	515.6	468.0	491.8
15	308 X CT 9A	7,088	7,317	7,203	24.90	24.66	24.78	14.81	14.81	14.51	487.0	422.9	454.9
13	308 X CT 5B	6,751	7,141	6,946	23.39	25.13	24.26	14.41	14.19	14.30	417.6	438.5	428.1
05	308 X Line 289	5,794	6,123	5,958	19.29	19.94	19.61	14.99	15.31	15.15	403.6	455.6	429.6
07	CT 9 X Ov. 3	6,978	7,200	7,090	23.49	24.43	23.96	14.85	14.73	14.79	429.4	428.1	428.8
03	CT 9 X EL 31	6,616	6,815	6,715	20.08	22.60	22.34	14.99	15.08	15.03	409.9	356.8	383.3
11	CT 9 X FC 503	6,570	6,723	6,647	21.68	22.45	22.06	15.15	14.98	15.06	368.8	404.6	386.7
02	129 X CT 5A	6,565	6,293	6,429	21.80	21.30	21.55	15.04	14.74	14.89	387.8	353.8	370.8
08	FC 502 X 00.5	6,940	6,451	6,696	23.14	21.83	22.48	15.01	14.79	14.90	439.9	396.9	418.4
Mean All Females		6,703	6,781	6,742	22.60	22.84	22.72	14.83	14.84	14.83	432.3	412.3	422.3
Sig. Difference: 5%													
Males Same Female		NS			NS			NS			46.7		
Females		700			1.07			0.42			46.2		
Males		NS			NS			NS			12.1		

Variance Table

Source Variation	DF	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F
Replications	7	50.54 X 10 ⁵	5.17**	45.04	5.81**	3.494	9.58**
Female	14	21.17 X 10 ⁵	2.16*	35.42	4.57**	1.351	3.71**
Error (A)	98	97.81 X 10 ⁴		7.75		0.365	
Male	1	36.01 X 10 ⁴	NS	3.50	NS	0.007	NS
Male X Female	14	37.56 X 10 ⁴	NS	4.01	NS	0.235	2.62**
Error (B)	105	24.91 X 10 ⁴		2.80		0.090	
Total	239	80.60 X 10 ⁴		8.05		0.384	

Table 1A. PERFORMANCE OF CMS-RESTORER VERSUS MENDELIAN-RESTORER HYBRIDS TEST 2, NORTH FARM, LOGAN, UTAH, 1966
8 & 16 Replications Respectively

Code	No.	Description	Amino N			Na			"K"			Beet count		
			+a	CMS	Mean	+a	CMS	Mean	+a	CMS	Mean	+a	CMS	Mean
14	AI-1 X Ov. 3		254.9	193.4	224.1	175.9	219.3	197.6	1169.0	1075.0	1122.0	657.7	70.1	67.9
06	AI-1 X CT 5B		263.5	203.0	233.3	182.1	203.4	192.8	1217.7	1130.0	1173.9	69.2	69.9	69.6
01	AI-1 X C672		270.8	230.4	250.6	235.9	251.6	243.8	1349.7	1326.6	1337.9	66.9	70.6	68.7
10	AI-1 X FC 503		227.1	248.5	237.8	206.8	228.8	217.8	1179.4	1152.1	1165.8	65.4	66.9	66.1
12	AI-1 X Line 289		299.5	347.5	323.5	180.3	150.4	165.3	1180.1	1137.4	1158.7	64.7	69.0	66.9
09	AI-1 X EL 31		328.4	255.3	291.8	211.5	245.9	228.7	1189.2	1097.1	1143.2	63.4	63.7	63.6
04	308 X EL 31		347.8	280.8	314.3	226.1	262.0	244.1	1261.4	1187.6	1224.5	69.5	69.5	69.5
15	308 X CT 9A		281.5	228.8	255.1	245.0	250.5	247.8	1287.1	1229.6	1258.4	63.5	69.9	66.7
13	308 X CT 5B		240.0	226.9	233.4	204.9	254.9	229.9	1152.2	1210.5	1181.4	68.9	67.5	68.2
05	308 X Line 289		271.8	328.5	300.1	176.2	205.5	190.9	1083.9	1175.4	1129.6	60.7	65.6	63.2
07	CT 9 X Ov. 3		260.1	238.4	249.3	200.6	259.1	229.9	1219.1	1196.2	1207.7	58.5	66.6	62.6
03	CT 9 X EL 31		269.0	213.4	241.1	176.1	173.6	174.9	1127.9	1050.5	1089.2	65.2	68.9	67.1
11	CT 9 X FC 503		192.3	233.3	212.8	155.4	169.9	162.6	1240.5	1243.9	1242.2	66.4	72.5	69.4
02	129 X CT 5A		206.7	155.8	181.3	177.0	187.5	182.3	1217.2	1177.5	1212.4	66.7	68.9	67.8
08	FC 502 X 00.5		241.9	214.0	227.9	204.3	190.5	197.4	1265.9	1210.9	1238.4	63.5	62.4	62.9
Mean All Females			263.7	239.8	251.8	197.2	216.9	207.2	1211.3	1173.4	1192.3	65.2	68.1	66.7
Sig. Difference: 5%														
Males Same Female			46.8		52.6		35.3		96.5		105.2		6.4	
Females														4.4
Males			12.1				9.1		24				5.2	

Variance Table

Source	Variation	DF	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F
Replications	7	96.15 X 10 ²	NS	76.31 X 10 ³	15.02**	15.06 X 10 ⁴	6.80**	269.92
Female	14	24.94 X 10 ³	4.50**	13.73 X 10 ³	2.70**	64.08 X 10 ³	2.89*	99.03
Error (A)	98	55.37 X 10 ²		50.80 X 10 ²		22.13 X 10 ³		40.23
Male	1	34.08 X 10 ³	15.53**	23.17 X 10 ³	18.62**	86.52 X 10 ³	9.28**	507.50
Male X Female	14	79.86 X 10 ²	3.64**	22.74 X 10 ²	1.83*	11.83 X 10 ³	NS	33.12
Error (B)	105	21.95 X 10 ²		12.44 X 10 ²		93.20 X 10 ²		40.90
Total	239	55.87 X 10 ²		58.99 X 10 ²		22.39 X 10 ³		52.24

Table 2. PERFORMANCE OF CMS-RESTORER AND MENDELIAN-RESTORER HYBRIDS, SOUTH FARM, LOGAN, UTAH, 1966
8 & 16 Replications

Code	No.	Description	Gross sugar			Tons per acre			Percent sucrose			Index		
			+a	CMS	Mean	+a	CMS	Mean	+a	CMS	Mean	+a	CMS	Mean
	12	AI-1 X Line 289	5488	5975	5732	17.79	19.40	18.59	15.49	15.46	15.48	339.6	337.9	338.8
	06	AI-1 X CT 5B	5486	5997	5741	17.90	19.76	18.83	15.35	15.17	15.26	310.4	308.0	309.2
	09	AI-1 X EL 31	5102	5171	5136	16.74	16.73	16.73	15.25	15.46	15.35	301.4	306.9	304.1
	01	AI-1 X C672	5045	4776	4910	16.48	16.15	16.31	15.33	14.81	15.07	343.3	358.4	350.8
	14	AI-1 X Ov. 3	4762	5516	5139	15.80	17.80	16.80	15.09	15.48	15.28	320.8	285.6	303.2
	10	AI-1 X FC 503	4639	4802	4720	15.31	15.92	15.62	15.15	15.05	15.10	298.8	327.4	313.1
	15	308 X CT 9A	5873	5965	5919	19.93	19.99	19.96	14.71	14.95	14.83	336.8	342.5	339.6
	13	308 X CT 5B	5790	6301	6045	19.13	20.95	20.04	15.11	15.07	15.09	324.6	310.9	317.8
	04	308 X EL 31	5438	4904	5171	18.21	16.31	17.26	14.88	15.00	14.94	334.8	316.5	325.6
	05	308 X Line 289	4811	5114	4963	15.61	16.77	16.19	15.34	15.24	15.29	311.1	316.6	313.9
	11	CT 9 X FC 503	5781	5591	5686	18.88	18.86	18.78	15.35	15.04	15.19	303.9	322.6	313.3
	07	CT 9 X Ov. 3	5627	7097	6362	18.25	23.25	20.75	15.41	15.30	15.36	370.6	345.8	358.2
	03	CT 9 X EL 31	5397	5171	5284	17.46	18.80	17.13	15.41	15.36	15.39	290.1	300.3	295.2
	02	129 X CT 5A	4815	4678	4747	15.33	15.16	15.26	15.70	15.39	15.54	292.5	330.3	311.4
	08	FC 502 X 00.5	6437	6614	6526	21.22	21.96	21.59	15.15	15.05	15.10	343.8	321.3	332.5
		Mean All Females	5366	5578	5472	17.60	18.38	17.99	15.25	15.19	15.22	321.5	322.1	321.8
		Sig. Difference: 5%												
		Males Same Female	752.0			2.39			0.31			37.2		
		Females			432.0			1.43			0.17			38.9
		Males	192.5			0.61			0.08			NS		

Variance Table									
Source Variation	DF	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F
Replications	7	10.61 X 106	7.11**	118.31	7.26**	1.358	5.67**	21.13 X 103	6.97**
Female	14	52.94 X 105	3.55**	61.50	3.77**	0.618	2.58**	54.44 X 102	1.80*
Error (A)	98	14.92 X 105		16.30		0.239		30.31 X 102	
Male	1	27.05 X 105	4.78*	35.81	6.27**	0.210	NS	19.50	NS
Male X Female	14	98.26 X 104	NS	10.26	1.80*	0.214	2.20*	16.87 X 102	NS
Error (B)	105	56.58 X 104		5.71		0.097		13.88 X 102	
Total	239	15.50 X 105		17.01		0.230		28.89 X 102	

Table 2A. PERFORMANCE OF CMS-RESTORER AND MENDELIAN-RESTORER HYBRIDS, SOUTH FARM, LOGAN, UTAH, 1966

8 & 16 Replications													
Code No.	Description	Amino N			Na			K			Beet count		
		+a	CMS	Mean	+a	CMS	Mean	+a	CMS	Mean	+a	CMS	Mean
06	AI-1 X CT 5B	120.8	102.6	111.7	94.4	113.6	104.0	1284.5	1290.4	1287.4	70.5	74.1	72.3
12	AI-1 X Line 289	147.6	151.9	149.8	111.5	115.3	113.4	1334.9	1334.6	1334.7	65.6	69.2	67.4
14	AI-1 X Ov. 3	124.1	91.1	107.6	110.9	118.6	114.8	1275.6	1238.4	1257.0	65.5	68.0	66.7
09	AI-1 X EL 31	119.3	121.9	120.6	109.9	126.8	118.3	1200.5	1275.7	1213.1	72.5	75.4	73.9
01	AI-1 X C672	109.1	104.4	106.8	122.8	130.1	126.4	1513.9	1510.2	1512.1	64.1	62.9	63.5
10	AI-1 X FC 503	110.3	121.3	115.8	96.8	125.5	111.0	1230.2	1305.4	1267.8	62.5	64.4	63.4
13	308 X CT 5B	112.6	109.8	111.1	103.4	99.6	101.5	1361.7	1293.7	1327.7	71.4	75.6	73.5
15	308 X CT 9A	109.1	113.8	111.4	135.6	160.1	147.9	1346.1	1362.2	1354.2	69.2	70.5	69.9
04	308 X EL 31	123.0	122.1	122.6	109.5	128.0	118.8	1349.2	1226.6	1287.9	67.4	67.5	67.4
05	308 X Line 289	117.5	126.6	122.1	102.3	105.4	103.8	1276.0	1263.6	1269.8	64.7	72.0	68.4
07	CT 9 A Ov. 3	156.7	123.1	139.9	170.5	140.0	165.3	1383.7	1424.5	1404.1	62.1	69.2	65.7
11	CT 9 X FC 503	114.8	118.3	116.5	83.5	102.3	93.4	1284.1	1318.0	1301.1	70.9	68.6	69.7
03	CT 9 X EL 31	120.9	111.4	116.1	97.0	99.3	98.1	1170.5	1247.1	1208.8	67.5	69.2	68.4
02	129 X CT 5A	102.6	125.1	113.9	80.3	105.4	92.8	1311.9	1380.6	1346.2	65.5	69.0	67.2
08	FC 502 X 00.5	120.5	115.8	118.1	108.5	104.8	106.7	1445.0	1317.6	1381.3	68.7	66.7	67.7
Mean All Females		120.6	117.3	118.9	110.4	118.4	114.4	1317.9	1315.9	1316.9	67.2	69.5	68.4
Sig. Difference: 5%													
Males Same Female		NS			48.0			107.1			6.6		
Females		NS			37.6			116.2			6.0		
Males		NS			NS			NS			1.7		
Variance Table													
Source Variation	DF	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F
Replications	7	6648.8	5.00**	10.61 X 10 ³	3.75**	16.71 X 10 ⁴	6.18**	323.71	4.42**	323.71	6.18**	158.02	2.16*
Female	14	2181.7	NS	63.05 X 10 ²	2.22*	97.32 X 10 ³	3.60*	158.02	2.16*	158.02	3.60*	73.28	7.14**
Error (A)	98	1329.1		28.32 X 10 ²		27.05 X 10 ³		73.28		73.28		312.82	NS
Male	1	660.0	NS	37.68 X 10 ²	NS	22.62 X 10 ²	NS	312.82	NS	312.82	NS	32.86	NS
Male X Female	14	939.5	NS	14.89 X 10 ²	NS	16.39 X 10 ³	NS	32.86	NS	32.86	NS	43.83	NS
Error (B)	105	780.1		23.17 X 10 ²		11.47 X 10 ³		43.83		43.83		71.28	NS
Total	239	1268.0		29.62 X 10 ²		27.69 X 10 ³		71.28		71.28			

Table 3. PERFORMANCE OF CMS-RESTORER VERSUS MENDELIAN-RESTORER HYBRIDS TEST 2, FARMINGTON, UTAH, 1966

8 & 16 Replications Respectively

Code No.	Description	Gross sugar			Tons per acre			Percent sucrose			Index	
		+a	CMS	Mean	+a	CMS	Mean	+a	CMS	Mean	+a	Mean
09	(AI-1 X EL 31)	11,184	11,338	11,261	37.25	37.41	37.33	15.05	15.18	15.11	510.5	462.0
14	(AI-1 X Ov. 3)	11,470	10,812	11,141	38.84	36.76	37.80	14.79	14.71	14.75	500.9	439.4
12	(AI-1 X Line 289)	11,166	10,514	10,840	36.48	34.49	35.48	15.33	15.26	15.29	386.3	522.0
01	(AI-1 X C672)	10,857	10,459	10,658	38.54	38.44	38.49	14.08	13.60	13.84	558.5	585.4
06	(AI-1 X CT 5B)	10,538	10,641	10,590	36.53	38.09	37.31	14.44	13.94	14.19	495.0	504.0
10	(AI-1 X FC 503)	9,940	10,149	10,045	33.85	34.13	33.99	14.71	14.91	14.81	444.8	431.5
13	(308 X CT 5B)	11,923	11,690	11,807	42.63	41.58	42.10	14.00	14.06	14.03	595.1	562.1
15	(308 X CT 9A)	11,385	11,913	11,649	40.99	43.49	42.24	13.89	13.71	13.80	586.6	571.6
04	(308 X EL 31)	11,344	10,791	11,067	38.74	37.30	38.02	14.64	14.49	14.56	592.1	544.5
05	(308 X Line 289)	9,953	10,052	10,002	33.04	33.53	33.28	15.09	14.99	15.04	515.1	475.9
03	(CT 9 X EL 31)	12,438	11,740	12,089	42.09	40.84	41.46	14.79	14.39	14.59	527.5	558.4
07	(CT 9 X Ov. 3)	11,356	11,230	11,293	38.51	37.86	38.19	14.74	14.83	14.78	487.3	476.3
11	(CT 9 X FC 503)	10,266	10,435	10,351	34.70	35.96	35.33	14.78	14.48	14.63	497.3	488.3
02	(129 X CT 5A)	11,378	11,598	11,488	39.81	40.50	40.16	14.28	14.31	14.29	473.1	479.9
08	(FC 502 X 00.5)	10,863	10,079	10,471	36.63	33.90	35.26	14.80	14.86	14.83	500.6	483.1
Mean		11,071	10,896	10,983	37.91	37.61	37.76	14.63	14.51	14.57	516.8	505.6
Sig Difference: 5%												
Males Same Female		550			1.79			0.32			44	
Females					872			0.88				
Males		142			NS			0.08			11	

Variance Table									
Source Variation	DF	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F
Reps.	7	11.47 X 10 ⁶	7.55**	148.23	9.77**	1.43	3.76**	12.10 X 10 ⁴	22.87**
Female	14	63.89 X 10 ⁵	4.21**	127.00	8.37**	3.30	8.64**	30.67 X 10 ³	5.80**
Error (A)	98	15.19 X 10 ⁵		15.17		0.38		52.93 X 10 ²	
Male	1	18.31 X 10 ⁵	6.07*	5.02	NS	0.74	7.07**	75.60 X 10 ²	3.94*
Male X Female	14	70.80 X 10 ⁴	2.34**	8.77	2.74**	0.20	1.88*	36.90 X 10 ²	1.91*
Error (B)	105	30.19 X 10 ⁴		3.20		0.10		19.36 X 10 ²	
Total	239	15.15 X 10 ⁵		19.94		0.45		86.11 X 10 ²	

Table 3A. PERFORMANCE OF CMS-RESTORER VERSUS MENDELIAN-RESTORER HYBRIDS TEST 2, FARMINGTON, UTAH, 1966

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8 & 16 Replications Respectively

	Amino "N"			"Na"			"K"			Beet count		
	+a	CMS	Mean	+a	CMS	Mean	+a	CMS	Female	+a	CMS	Mean
(AI-1 X EL 31)	291.4	256.3	273.8	216.5	226.8	221.6	1578.5	1447.8	1513.1	84.1	90.1	87.1
(AI-1 X Ov. 3)	276.0	211.9	243.9	215.8	257.6	235.7	1534.3	1406.9	1470.6	80.0	78.9	79.4
(AI-1 X Line 289)	292.0	356.6	324.3	162.6	176.0	169.3	1572.3	1501.0	1536.6	84.1	83.9	84.0
(AI-1 X C672)	223.8	240.5	232.1	286.5	302.8	294.6	1811.1	1756.8	1783.9	81.5	79.9	80.7
(AI-1 X CT 5B)	232.5	212.5	222.5	236.4	297.6	267.0	1579.8	1522.4	1551.1	78.1	82.4	80.3
(AI-1 X FC 503)	208.9	201.4	205.1	200.3	223.3	211.8	1479.4	1436.4	1457.9	80.1	79.4	79.8
(308 X CT 9A)	308.9	270.1	289.5	256.1	297.3	276.6	1708.5	1650.3	1679.4	83.0	85.4	84.2
(308 X CT 5B)	269.5	234.5	252.0	266.5	309.6	288.1	1686.6	1740.3	1713.4	85.5	83.1	84.3
(308 X EL 31)	356.5	300.3	328.4	189.9	230.0	209.9	1768.6	1610.0	1609.3	84.1	87.1	85.6
(308 X Line 289)	325.1	253.4	289.3	174.6	203.5	189.1	1539.0	1545.0	1542.0	78.8	78.9	78.8
(CT 9 X Ov. 3)	281.8	263.4	272.6	208.4	292.0	250.2	1752.6	1730.5	1741.2	76.0	83.4	79.7
(CT 9 X EL 31)	248.6	244.0	246.3	223.0	191.5	207.3	1630.6	1575.9	1603.2	82.3	83.6	82.9
(CT 9 X FC 503)	248.4	223.3	235.8	172.5	203.0	187.8	1698.4	1645.4	1671.9	82.5	87.3	84.9
(129 X CT 5A)	209.0	201.4	205.2	199.3	229.4	214.3	1583.1	1596.5	1589.8	84.3	82.8	83.5
(FC 502 X 00.5)	252.0	230.1	241.1	196.5	209.0	202.8	1678.4	1646.6	1662.5	78.9	76.9	77.9
Mean	268.3	246.6	257.5	213.7	243.3	228.5	1640.1	1587.4	1613.8	81.6	82.9	82.2
Sig Diff:5%												
Males Same Female	44	38	77	NS								
Females	46	44	84	NS								
Males	12	10	20	NS								
Variance Table												
Source	Varia.	DF	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F
Reps.	7	12.70 X 10 ⁴	28.91**	12.51 X 10 ³	3.22**	32.93 X 10 ⁴	18.94**	42.66	NS	NS	NS	NS
Female	14	23.36 X 10 ³	4.74**	23.96 X 10 ³	6.16**	16.19 X 10 ⁴	9.31**	129.42	NS	NS	NS	NS
Error (A)	98	43.92 X 10 ²		38.88 X 10 ²		17.38 X 10 ³		79.01				
Male	1	28.12 X 10 ³	14.20**	52.69 X 10 ³	37.00**	16.63 X 10 ⁴	27.50**	102.70	NS	NS	NS	NS
Male X Female	14	45.12 X 10 ²	2.28**	26.81 X 10 ²	1.88*	12.54 X 10 ³	2.08*	39.51				
Error (B)	105	19.76 X 10 ²		14.23 X 10 ²		60.37 X 10 ²		50.17				
Total	239	81.38 X 10 ²		43.67 X 10 ²		30.34 X 10 ³		66.01				

Table 4. PERFORMANCE OF CMS-RESTORER VERSUS MENDELIAN-RESTORER HYBRIDS COMBINED LOCATIONS, UTAH, 1966
24 & 48 Observations Respectively

Code	Description	Gross sugar			Tons per acre			Percent sucrose			Index		
		+a	CMS	Mean	+a	CMS	Mean	+a	CMS	Mean	+a	CMS	Mean
14	AI-1 X Ov. 3	7773.0	7890.0	7831.5	26.02	26.28	26.15	14.98	15.07	15.02	409.7	360.5	385.1
06	AI-1 X CT 5B	7659.2	7903.4	7781.3	25.91	27.10	26.50	14.91	14.72	14.81	410.4	394.2	402.3
12	AI-1 X Line 289	7680.6	7675.0	7677.8	25.09	25.00	25.04	15.32	15.40	15.35	421.0	434.7	427.8
09	AI-1 X EL 31	7548.5	7598.6	7573.5	25.10	25.09	25.09	15.08	15.18	15.13	428.0	394.7	411.4
01	AI-1 X C672	7540.1	7505.0	7522.5	26.03	26.57	26.30	14.65	14.30	14.47	459.2	464.6	461.9
10	AI-1 X FC 503	7033.9	7115.4	7074.7	23.77	23.95	23.86	14.84	14.87	14.86	383.7	394.0	388.8
15	308 X CT 9A	8294.9	8324.3	8309.6	29.15	28.74	28.95	14.31	14.61	14.46	473.0	442.5	457.7
13	308 X CT 5B	7975.5	8451.6	8213.6	27.84	29.85	28.85	14.47	14.32	14.40	437.0	440.3	438.6
04	308 X EL 31	7999.6	7477.5	7738.5	27.29	25.65	26.47	14.66	14.63	14.65	480.8	443.0	461.9
05	308 X Line 289	6852.5	7096.3	6974.4	22.65	23.41	23.03	15.14	15.18	15.16	410.0	416.0	413.0
07	CT 9 X Ov. 3	8347.8	8679.1	8513.4	27.94	29.50	28.72	15.02	14.80	14.91	442.5	444.1	443.3
11	CT 9 X FC 503	7539.1	7583.3	7561.2	25.08	25.70	25.39	15.09	14.83	14.96	390.0	405.2	397.6
03	CT 9 X EL 31	7789.6	7738.5	7764.1	26.02	25.75	25.89	15.05	15.09	15.07	395.7	377.7	386.7
02	129 X CT 5A	7586.1	7522.9	7554.5	25.65	25.65	25.65	15.00	14.81	14.91	384.5	388.0	386.2
08	FC 502 X 00.5	8079.9	7715.1	7897.5	26.99	25.90	26.45	14.99	14.90	14.94	428.1	400.4	414.2
Mean All Females		7713.4	7751.7	7732.5	26.04	26.28	26.16	14.90	14.85	14.87	423.6	413.3	418.5
Sig. Difference: 5%													
Males Same Female		352			1.14			0.18			2.5		
Females		502			1.59			0.27			34		
Males		NS			NS			.05			6.0		

Variance Table													
Source Variation	DF	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F
Replications	7	1637 X 10 ⁴	10.82**	193.31	12.75**	1.352	3.17**	57.56 X 10 ³	3.17**	57.56 X 10 ³	3.17**	57.56 X 10 ³	8.49**
Locations	2	1999 X 10 ⁶	132.07**	25586.50	1687.05**	25.580	60.07**	21.56 X 10 ⁵	60.07**	21.56 X 10 ⁵	60.07**	21.56 X 10 ⁵	318.24**
Females	14	8076 X 10 ³	5.33**	138.04	9.10**	3.680	8.84**	38.60 X 10 ³	8.84**	38.60 X 10 ³	8.84**	38.60 X 10 ³	5.70**
Loc. & Female	28	2862 X 10 ³	1.89**	42.94	2.83**	0.800	1.87	80.06 X 10 ²	1.87	80.06 X 10 ²	1.87	80.06 X 10 ²	NS
Error (A)	308	1514 X 10 ³	NS	15.17	NS	0.430	5.22	67.76 X 10 ²	5.22	67.76 X 10 ²	5.22	67.76 X 10 ²	10.25**
Males	1	2650 X 10 ²	NS	10.51	NS	0.510	NS	18.82 X 10 ³	NS	18.82 X 10 ³	NS	18.82 X 10 ³	3.48*
Loc. X Male	2	2316 X 10 ³	6.22**	16.90	4.33*	0.223	3.68**	63.99 X 10 ²	3.68**	63.99 X 10 ²	3.68**	63.99 X 10 ²	2.93**
Female X Male	14	7479 X 10 ²	2.00**	10.75	2.76**	0.360	NS	53.90 X 10 ²	NS	53.90 X 10 ²	NS	53.90 X 10 ²	1.59*
Loc. X Fem. X Male	28	6590 X 10 ²	1.77*	6.14	1.57*	0.144	0.097	29.17 X 10 ²	0.097	29.17 X 10 ²	0.097	29.17 X 10 ²	18.37 X 10 ²
Error (B)	315	3723 X 10 ²		3.90		0.097		11.59 X 10 ³		11.59 X 10 ³		11.59 X 10 ³	
Total	719	6848 X 10 ³		86.13		0.426							

Table 4A. PERFORMANCE OF CMS-RESTORER VERSUS MENDELIAN-RESTORER HYBRIDS, COMBINED LOCATIONS, UTAH, 1966
24 & 48 Observations Respectively

Code		Amino N			Na			"K"			Beet count		
No.	Description	+a	CMS	Mean	+a	CMS	Mean	+a	CMS	Mean	+a	CMS	Mean
14	AI-1 X Ov. 3	218.3	165.5	191.9	167.5	198.5	183.0	1326.3	1240.1	1283.2	70.4	72.3	71.4
06	AI-1 X CT 5B	205.6	172.7	189.1	171.0	204.9	187.9	1360.7	1314.2	1337.5	72.6	75.5	74.0
12	AI-1 X Line 289	246.4	285.3	265.8	151.5	147.2	149.3	1362.4	1324.3	1343.4	71.5	74.0	72.8
09	AI-1 X EL 31	246.3	211.1	228.7	179.3	199.8	189.5	1322.7	1256.9	1289.8	73.3	76.4	74.9
01	AI-1 X C672	201.2	191.7	196.5	215.0	228.2	221.6	1558.1	1531.2	1544.6	70.8	71.1	71.0
10	AI-1 X FC 503	182.1	190.4	186.2	167.9	192.4	180.1	1296.3	1298.0	1297.1	69.3	70.2	69.8
15	308 X CT 9A	233.2	204.2	218.7	212.2	236.0	224.1	1447.2	1414.0	1430.6	71.9	75.2	73.6
13	308 X CT 5B	207.4	190.4	198.9	191.6	221.4	206.5	1400.2	1414.8	1407.5	75.2	75.4	75.3
04	308 X EL 31	275.7	234.4	255.1	175.2	206.7	190.9	1459.7	1341.4	1400.6	73.7	74.7	74.2
05	308 X Line 289	238.1	236.2	237.1	151.0	171.5	161.2	1299.6	1328.0	1313.8	68.1	72.2	70.1
07	CT 9 X Ov. 3	232.8	208.3	220.6	199.8	230.4	215.1	1451.8	1450.4	1451.1	65.5	73.1	69.3
11	CT 9 X FC 503	185.1	191.6	188.4	137.1	158.7	147.9	1407.7	1402.4	1405.0	73.2	76.1	74.7
03	CT 9 X EL 31	212.8	189.6	201.2	165.4	154.8	160.1	1309.7	1291.2	1300.4	71.7	73.9	72.8
02	129 X CT 5A	172.8	160.7	166.8	152.2	174.1	163.1	1380.7	1384.9	1382.8	72.2	73.5	72.9
08	FC 502 X 00.5	204.8	186.6	195.7	269.7	168.1	168.9	1463.1	1391.7	1427.4	70.4	68.7	69.5
Mean All Females		217.5	201.2	209.4	173.8	192.8	183.3	1389.8	1358.9	1374.4	71.3	73.5	72.4
Sig. Difference: 5%													
Males Same Female		23.5			23.5			54.6			3.9		
Females		31.3			29.1			23.0			3.4		
Males		6.0			6.1			14.1			1.0		
Variance Table													
Source Variation		DF	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F	Mean Sq.	F	F
Replications		7	41.87 X 10 ³	7.11**	40.34 X 10 ³	7.91**	18.53 X 10 ⁴	5.85**	335.89	4.93**	335.89	4.93**	
Locations		2	14.75 X 10 ⁵	250.56**	88.19 X 10 ⁴	173.00**	11.25 X 10 ⁶	355.14**	17427.00	25.59**	17427.00	25.59**	
Females		14	36.59 X 10 ³	6.22**	30.36 X 10 ³	5.95**	26.24 X 10 ⁴	8.29**	208.21	3.06**	208.21	3.06**	
Loc. X Female		28	69.46 X 10 ²	NS	68.22 X 10 ²	NS	30.41 X 10 ³	NS	89.13	NS	89.13	NS	
Error (A)		308	58.86 X 10 ²		50.98 X 10 ²		31.67 X 10 ³		68.09		68.09		
Males		1	47.62 X 10 ³	28.86**	65.45 X 10 ³	39.40**	17.13 X 10 ⁴	19.16**	845.00	18.79**	845.00	18.79**	
Loc. X Male		2	76.18 X 10 ²	4.62*	70.84 X 10 ²	4.26*	40.84 X 10 ³	4.57*	39.01	NS	39.01	NS	
Female X Male		14	62.79 X 10 ²	3.81*	23.31 X 10 ²	1.40*	20.08 X 10 ³	2.25	53.15	NS	53.15	NS	
Loc. X Fem. X Male		28	35.79 X 10 ²	2.17**	20.57 X 10 ²	NS	10.33 X 10 ³	NS	26.17	NS	26.17	NS	
Error (B)		315	16.50 X 10 ²		16.61 X 10 ²		89.49 X 10 ²		49.96		49.96		
Total		719	90.86 X 10 ²		68.50 X 10 ²		58.02 X 10 ³		111.46		111.46		

Table 5. MALE COMPARISONS AT ALL LOCATIONS AND COMBINED LOCATION TEST 2, LOGAN, UTAH, 1966
120 Obs. each location, 360 Obs. combined locations

Description	Gross sugar			Comb.	Tons per acre			Comb.	Sucrose			Comb.
	1	2	3		1	2	3		1	2	3	
(129 + a X R _f) male	6703	5366	11,071	7713	22.60	17.60	37.91	26.03	14.83	15.25	14.63	14.90
(129 CMS X R _f) male	6781	5578	10,896	7752	22.84	18.38	37.62	26.28	14.84	15.19	14.51	14.85
Mean	6742	5472	10,983	7733	22.72	17.99	37.76	26.16	14.83	15.22	14.57	14.87
S. E. of Mean Diff.	64	97	71	79	0.22	0.31	0.73	0.26	0.04	0.04	0.04	0.02
Sig. Diff. 5%	NS	194	142	NS	NS	0.62	NS	NS	NS	NS	0.08	0.04
F Values	NS	4.78	6.07	NS	NS	6.27	NS	NS	NS	NS	7.07	5.22

Description	Index			Amino "N"			Na					
	1	2	3	Comb.	1	2	3	Comb.	1	2	3	Comb.
(129 + a X Rf)	432.3	321.5	516.8	423.6	263.7	120.6	268.3	217.5	197.2	110.4	213.7	173.8
(129 CMS X Rf)	412.3	322.0	505.6	413.3	239.8	117.3	246.6	201.2	216.9	118.4	243.3	192.8
Mean	422.3	321.8	511.2	418.4	251.8	118.9	257.5	209.4	207.0	114.4	228.5	183.3
S. E. of Mean Diff.	6.0	5.0	5.7	3.2	6.0	3.6	5.7	3.0	4.5	6.2	4.9	3.0
Sig. Diff. 5%	12.0	NS	11.0	6.4	12.0	NS	11.0	6.0	9.0	NS	10.0	6.1
F Values	10.99	NS	3.94	10.25	15.53	NS	14.20	28.86	18.62	NS	37.00	39.40

Description	"K"			Comb.	Beet count		
	1	2	3		1	2	3
(129 + a X R _f)	1211.3	1317.9	1640.1	1389.8	65.2	67.2	81.6
(129 CMS X R _f)	1173.4	1315.9	1587.4	1358.9	68.1	69.5	82.9
Mean	1192.3	1316.9	1613.8	1374.4	66.7	68.4	82.2
S. E. of Mean Diff.	12.5	13.8	10.0	7.05	2.6	1.7	2.9
Sig. Diff. 5%	25.0	NS	20.0	14.10	5.2	3.4	NS
F Values	9.28	NS	27.50	19.16	12.4	7.14	NS

Significant F Values: 5% = 3.94, 1% = 6.90
Significant F Values Combined: 5% = 3.89, 1% = 6.76

Test 3

Test 3 was a comparison of three double cross hybrids and their component single crosses. The test was grown at two locations: Utah State University Evans Farm, six miles south of Logan, and the Greenville Farm, one mile north of Logan.

Results of the performance at the North Farm, South Farm, and combined locations are respectively shown in Tables 1, 2, and 3. SLC 128 X Ov. 1, SLC 129 X Ov. 1, and SLC 129 X EL 31, were the best yielding single crosses in the test, while (CT 9 X CT 5B) X (SLC 129 X Ov. 1) was the highest yielding double cross hybrid. CT 9 X R_f and CT 9 X SLC 129 were the lowest in yield at both locations. Highly significant differences were noted for all variables for locations with the exception of Na and K measurements (Table 3). Higher gross sugar, higher tonnage, and higher impurity index were observed for the North Farm experiment. The amino nitrogen uptake on the South Farm was about half that of the North Farm. In general, the varieties performed similarly at the two locations, however, significant differences were observed for variety times location interactions for potassium and impurity index.

Comparisons were made of the mean performance of the six related single crosses and the four non-parental single crosses, with each double cross hybrid. This was done for each location and for combined locations (Tables 4, 5, and 6). At the North Farm all comparisons were non-significant except for impurity index with (CT 9 X CT 5B) X (129 X Ov. 1) and (129 X Ov. 1) X (CT 9 X R_f) hybrids. This was also true for amino N except with the (129 X Ov. 1) X (CT 9 X R_f) double cross.

At the South Farm there were no significant differences between single cross averages and the respective double crosses. Combining locations resulted in a significant difference between the (CT 9 X CT 5B) X (129 X Ov. 1) double cross and the four non-parental single crosses for sucrose percent. The difference was so small (0.5%), however, it has little meaning. The amino N measurements also showed significance with the double cross cited above and (129 X Ov. 1) X (CT 9 X R_f). The true meaning of the significant differences for impurity factors will depend upon further tests.

Data indicate that for most of the factors measured, the single cross average would give a good indication of the performance of the double cross. No advantage in prediction was noted for the 4 non-parental versus the six single crosses composing the hybrid.

TABLE 1 FOURWAY HYBRIDS VERSUS SINGLE CROSSES VARIETY TEST 3 NORTH FARM LOGAN, UTAH 1966
17 HYBRID COMBINATIONS, 4 REPLICATIONS

Variety code	Description	Acre Yield		Percent sugar	Impurity index	PPM			Av. Beets per plot
		Gross sugar	Tons beets			Amino N	Na	K	
13	128 X Ov. 1	9448	30.9	15.3	481	389	155	1167	82
12	129 X Ov. 1	8612	29.1	14.8	487	338	165	1298	72
14	CT9 X Ov. 1	8266	28.1	14.7	499	325	182	1376	78
06	308H01 X EL 31	8152	29.9	13.6	711	440	239	1773	70
02	(CT9 X CT5B) X (129 X Ov.1)	8091	27.5	14.7	381	204	136	1226	80
10	CT9 X CT5B	8084	26.9	15.0	388	262	121	1103	74
09	129 X CT5B	8051	27.7	14.5	393	251	135	1085	79
03	(129 X Ov.1) X (CT9 X R _f)	8002	27.1	14.7	410	221	130	1351	79
11	308H01 X CT5B	7907	29.5	13.4	556	300	210	1478	74
17	308H01 X R _f	7889	28.2	14.0	578	306	188	1740	76
01	(129 X EL31)X (129 X Ov.1)	7804	26.9	14.5	474	332	159	1190	84
15	129 X R _f	7650	25.9	14.8	444	246	149	1421	72
04	129 X EL31	7336	24.5	14.9	422	288	131	1186	78
05	128 X EL31	7176	24.2	14.8	408	260	128	1196	68
07	128 X 129	6740	23.5	14.3	448	290	129	1221	64
16	CT9 X R _f	6563	21.9	15.0	446	235	112	1576	48
08	CT9 X 129	6481	22.3	14.5	443	283	131	1256	56
Mean All Varieties		7778	26.7	14.57	469	292	153	1332	73
S. E. of Mean		362.5	1.21	0.12	23.57	32.59	17.89	71.32	4.77
Sig. Diff. 5%		1025	3.42	0.34	67	92	51	202	13
Coef. Variation		9.32	9.05	1.65	10.05	22.28	23.39	10.71	13.12
Calculated F Values		4.29	4.78	17.03	12.55	3.42	3.68	8.40	3.94

Significant F Values 5% = 1.86 1% = 2.40

TABLE 2 FOURWAY HYBRIDS VERSUS SINGLE CROSSES VARIETY TEST 3 SOUTH FARM LOGAN, UTAH 1966
17 HYBRID COMBINATIONS, 4 REPLICATIONS

Variety code	Description	Acre Yield		Percent sugar	Impurity index	PPM			Av. Beets per plot
		Gross sugar	Tons beets			Amino N	Na	K	
04	129 X EL31	8472	26.9	15.5	324	177	101	1132	65
13	128 X Ov. 1	6678	21.3	15.7	315	140	138	1215	73
12	129 X Ov. 1	6645	22.0	15.1	394	165	161	1484	69
10	CT9 X CT5B	6107	20.0	15.2	355	126	175	1399	63
11	308HO1 X CT5B	5996	21.3	14.1	474	164	203	1705	75
09	129 X CT5B	5915	20.3	14.4	332	125	123	1226	75
14	CT9 X Ov. 1	5777	19.5	14.9	362	119	151	1409	69
17	308HO1 X Rf	5724	20.1	14.3	408	136	178	1523	63
15	129 X Rf	5654	18.9	15.1	341	107	140	1406	59
02	(CT9 X CT5B) X (129 X Ov.1)	5647	18.8	15.0	351	129	158	1365	61
01	(128 X EL31) X (129 X Ov.1)	5376	18.1	14.8	360	148	161	1304	70
03	(129 X Ov.1) X (CT9 X Rf)	5332	17.7	15.0	349	107	140	1437	55
05	128 X EL 31	5176	16.5	15.7	272	131	096	1050	62
07	128 X 129	4899	16.5	14.8	321	117	119	1260	53
06	308HO1 X EL 31	4309	14.3	15.1	427	214	161	1476	61
16	CT9 X Rf	3415	18.0	15.6	342	138	109	1414	36
08	CT9 X 129	3238	10.8	14.9	332	113	136	1397	43
Mean All Varieties		5551	18.5	15.0	357	139	144	1365	62
S. E. of Mean		1113	3.48	.30	24	18	18	71	4.38
Sig. Diff. 5%		NS	NS	0.85	68	51	51	201	12
Coef. Variation		40.1	37.8	3.98	13.68	26.5	24.5	10.4	14.1
Calculated F Values		NS	NS	2.34	3.76	2.32	2.65	4.87	5.81
Significant F. Values		5% = 1.86		1% = 2.40					

TABLE 3 FOURWAY HYBRIDS VERSUS SINGLE CROSSES VARIETY TEST 3 COMBINED LOCATIONS 1966
17 HYBRIDS, 8 REPLICATIONS

Variety code	Description	Acre Yield		Percent sugar	Impurity index	PPM			Av. Beets per plot
		Gross sugar	Tons beets			Amino N	Na	K	
13	128 X Ov. 1	8063	26.1	15.5	398	265	147	1191	77
04	129 X EL31	7904	25.7	15.2	373	232	116	1159	72
12	129 X Ov. 1	7629	25.5	14.9	441	252	163	1391	71
10	CT9 X CT5B	7096	23.5	15.1	372	194	148	1251	68
14	CT9 X Ov. 1	7021	23.8	14.8	431	222	166	1392	73
09	129 X CT5B	6983	24.0	14.5	363	188	129	1155	77
11	308H01 X CT5B	6952	25.4	13.7	515	232	206	1592	75
02	(CT9 X CT5B) X (129 X Ov. 1)	6869	23.1	14.9	366	167	147	1295	70
17	308H01 X Rf	6807	24.2	14.1	493	221	183	1632	70
03	(129 X Ov. 1) X (CT9 X Rf)	6667	22.4	14.9	380	164	135	1394	67
15	129 X Rf	6652	22.4	14.9	393	177	145	1413	66
01	(128 X EL31) X (129 X Ov. 1)	6590	22.5	14.7	417	240	160	1247	77
06	308H01 X EL31	6230	22.1	14.3	569	327	200	1625	66
05	128 X EL31	6176	20.3	15.3	340	196	112	1123	65
07	128 X 129	5819	20.0	14.6	384	204	124	1241	59
16	CT9 X Rf	4989	16.4	15.3	394	187	111	1495	42
08	CT9 X 129	4860	16.6	14.7	388	198	134	1326	50
Mean All Varieties		6665	22.6	14.9	413	216	149	1348	67
S. E. of Mean		584.9	1.84	0.16	17.0	19.0	13.0	50.0	3.0
Sig. Diff. 5%		1654	5.20	0.45	48	53	36	142	9
Calculated F Values									
Varieties		2.22	2.42	7.63	12.89	4.78	5.16	10.56	8.85
Locations		245.29	208.91	4.18	8.39	79.14	NS	NS	6.62
Var. & Loc.		NS	NS	NS	3.13	NS	NS	2.63	NS
Significant F Values, Varieties and Varieties X Locations					Locations	5% = 1.75	1% = 2.19		
					Locations	5% = 3.94	1% = 6.90		

Table 4. DOUBLE CROSS HYBRID VERSUS MEAN OF SIX SINGLE CROSSES
AND FOUR NON-PARENTAL SINGLE CROSSES, NORTH FARM, LOGAN, UTAH, 1966

Variety code	Description	Acre yield		Percent sugar	Impurity index	PPM		
		Gross sugar	Tons beets			Amino N	Na	K
13	(128 X Ov. 1)	9448	39.9	15.3	481	389	155	1167
12	(129 X Ov. 1)	8612	29.1	14.8	487	338	165	1298
06	(308 X EL 31)	8152	29.9	13.6	711	440	239	1773
04	(129 X EL 31)	7336	24.5	14.9	422	288	131	1186
05	(128 X EL 31)	7176	24.2	14.8	408	260	128	1196
07	(128 X 129)	6740	23.5	14.3	448	290	129	1221
	Mean 6 S.C.	7911	28.5	14.6	493	334	158	1307
01	(128 X EL 31) X (129 X Ov. 1)	7804	26.9	14.5	474	332	159	1190
Mean	4 Non-Parent S.C.	7920	29.45	14.74	516	352	164	1337
Calculated F								
	Hybrids versus 6 S.C.	NS	NS	NS	NS	NS	NS	NS
	Hybrids versus 4 S.C.	NS	NS	NS	NS	NS	NS	NS
12	(129 X Ov. 1)	8612	29.1	14.8	487	338	165	1298
14	(CT 9 X Ov. 1)	8266	28.1	14.7	499	325	182	1376
10	(CT 9 X CT 5B)	8084	26.9	15.9	388	262	121	1103
09	(129 X CT 5B)	8051	27.7	14.5	393	251	135	1085
11	(308 X CT 5B)	7907	29.5	13.3	556	300	210	1478
08	(CT 9 X 129)	6481	22.3	14.5	443	283	131	1256
	Mean 6 S.C.	7900	27.3	14.6	461	293	157	1266
02	(CT 9 X CT 5B) X (129 X Ov. 1)	8091	27.5	14.7	381	204	136	1226
Mean	4 Non-Parent S.C.	7684	26.7	14.6	472	293	161	1303
Calculated F								
	Hybrids versus 6 S.C.	NS	NS	NS	9.87**	6.39*	NS	NS
	Hybrids versus 4 S.C.	NS	NS	NS	11.92**	5.97*	NS	NS
12	(129 X Ov. 1)	8612	29.1	14.8	487	338	165	1298
14	(CT 9 X Ov. 1)	8266	28.1	14.7	499	325	182	1376
17	(308 X R _f)	7889	28.2	14.0	578	306	188	1740
15	(129 X R _f)	7650	25.9	14.8	444	246	149	1421
16	(CT 9 X R _f)	6563	21.9	15.0	446	235	112	1576
08	(CT 9 X 129)	6481	22.3	14.5	443	283	131	1256
	Mean 6 S.C.	7578	25.9	14.6	483	289	155	1445
03	(129 X Ov. 1) X (CT 9 X R _f)	8002	27.1	14.7	410	221	130	1351
Mean	4 Non-Parent S.C.	7572	26.1	14.5	491	290	163	1448
Calculated F								
	Hybrids versus 6 S.C.	NS	NS	NS	8.22**	NS	NS	NS
	Hybrids versus 4 S.C.	NS	NS	NS	9.45**	NS	NS	NS

Significant "F" Values:

5% = 4.04

1% = 1.19

Table 5. FOURWAY HYBRIDS VERSUS SIX AND
FOUR SINGLE CROSS, SOUTH FARM, LOGAN, UTAH, 1966

Variety code	Description	Acre yield			Impurity index	PPM		
		Gross sugar	Tons beets	Percent sugar		Amino N	Na	K
13	(129 X Ov. 1)	6678	21.3	15.7	315	140	138	1215
04	(129 X EL 31)	8472	26.9	15.5	324	177	101	1132
12	(129 X Ov. 1)	6645	22.0	15.1	394	165	161	1484
05	(128 X EL 31)	5176	16.5	15.7	27.2	131	096	1050
07	(128 X 129)	4899	16.5	14.8	321	117	119	1260
06	(308 X EL 31)	4309	15.1	15.1	427	214	161	1476
	Mean 6 S.C.	6030	19.7	15.3	342	157	129	1270
01	(128 X EL 31) X (129 X Ov. 1)	5376	18.1	14.8	360	148	161	1304
Mean	4 Non-Parent S.C.	6081	20.1	15.1	367	168	136	1338
12	(129 X Ov. 1)	6645	22.0	15.1	394	165	161	1484
10	(CT 9 X CT 5B)	6107	20.0	15.2	355	126	175	1399
14	(CT 9 X Ov. 1)	5777	19.5	14.9	362	119	151	1409
09	(129 X CT 5B)	5915	20.3	14.4	332	125	123	1226
11	(308 X CT 5B)	5996	21.3	14.1	474	164	203	1705
08	(CT 9 X 129)	3238	10.8	14.9	332	113	136	1397
	Mean 6 S.C.	5611	19.0	14.8	375	135	158	1437
02	(CT 9 X CT 5B) X (129 X Ov. 1)	5647	18.8	15.0	351	129	158	1304
Mean	4 Non-Parent S.C.	5279	17.9	14.8	381	131	166	1473
12	(129 X Ov. 1)	6645	22.0	15.1	394	165	161	1484
14	(CT 9 X Ov. 1)	5777	19.5	14.9	362	119	151	1409
17	(308 X R _f)	5724	20.1	14.3	408	136	178	1523
15	(129 X R _f)	5654	18.9	15.1	341	107	140	1406
16	(CT 9 X R _f)	3415	10.9	15.6	342	138	109	1414
08	(CT 9 X 129)	3238	10.8	14.9	332	113	136	1397
	Mean 6 S.C.	5076	17.0	15.0	363	130	146	1439
03	(129 X Ov. 1) X (CT 9 X R _f)	5332	17.7	15.0	349	107	140	1437
Mean	4 Non-Parent S.C.	5098	17.3	14.8	361	119	151	1434

Table 6. FOURWAY HYBRIDS VERSUS SIX AND FOUR
SINGLE CROSS, COMBINED LOCATIONS, LOGAN, UTAH, 1966

Variety code	Description	Acre yield		Percent sugar	Impurity index	PPM		
		Gross sugar	Tons beets			Amino N	Na	K
13	(128 X Ov. 1)	8063	26.1	15.5	398	265	147	1191
04	(129 X EL 31)	7904	25.7	15.2	373	232	116	1159
12	(129 X Ov. 1)	7629	25.5	14.9	441	252	163	1391
06	(308 X EL 31)	6230	22.1	14.3	569	327	200	1625
05	(128 X EL 31)	6176	20.3	15.3	340	196	112	1123
07	(129 X 129)	5820	20.0	14.6	384	204	124	1241
	Mean 6 S.C.	6970	23.3	15.0	418	246	144	1288
01	(128 X EL 31) X (129 X Ov. 1)	6590	22.5	14.7	417	240	160	1247
Mean	4 Non-Parent S.C.	7004	23.5	14.9	431	257	147	1304
Calculated F								
Hybrids versus 6 S.C.		NS	NS	NS	NS	NS	NS	NS
Hybrids versus 4 S.C.		NS	NS	NS	NS	NS	NS	NS
12	(129 X Ov. 1)	7629	25.5	14.9	441	252	163	1391
10	(CT 9 X CT 5B)	7096	23.5	15.1	372	194	148	1251
14	(CT 9 X Ov. 1)	7021	23.8	14.8	231	222	166	1392
09	(129 X CT 5B)	6983	24.0	14.5	363	188	129	1115
11	(308 X CT 5B)	6952	25.4	13.7	515	232	206	1592
08	(CT 9 X 129)	4860	16.6	14.7	388	198	134	1326
	Mean 6 S.C.	6757	23.1	14.6	385	214	158	1345
02	(CT 9 X CT 5B) X (129 X Ov. 1)	6869	23.1	14.9	366	167	147	1295
Mean	4 Non-Parent S.C.	6454	22.5	14.4	374	210	159	1356
Calculated F								
Hybrids versus 6 S.C.		NS	NS	NS	NS	5.41*	NS	NS
Hybrids versus 4 S.C.		NS	NS	7.73**	NS	4.23*	NS	NS
12	(129 X Ov. 1)	7629	25.5	14.9	441	252	163	1391
14	(CT 9 X Ov. 1)	7021	23.8	14.8	231	222	166	1392
17	(308 X Rf)	6807	24.2	14.1	493	221	183	1632
15	(129 X Rf)	6652	22.4	14.9	393	177	145	1413
16	(CT 9 X Rf)	4989	16.4	15.3	394	187	111	1495
08	(CT 9 X 129)	4860	16.6	14.7	388	198	134	1326
	Mean 6 S.C.	6326	21.5	14.8	390	206	151	1442
03	(129 X Ov. 1) X (CT 9 X Rf)	6667	22.4	14.9	380	164	135	1394
Mean	4 Non-Parent S.C.	6335	21.8	14.6	376	205	157	1441
Calculated F								
Hybrids versus 6 S.C.		NS	NS	NS	NS	4.32*	NS	NS
Hybrids versus 4 S.C.		NS	NS	NS	NS	3.84*	NS	NS

Significant "F" Values:

5% = 3.94

1% = 6.90

Test 4

Test 4 was designed to compare the performance of 2n, 3n, and 4n hybrids. There were 3 tetraploid, 10 triploid, and 12 diploid varieties developed from the same inbreds in the test. The triploids were crosses between the 2n and 4n lines.

Due to small quantities of seed and poor seed germination the varieties were planted in the field in alternate single row plots with the uniform variety 1101. This was done to minimize possible differences in yield due to border effects caused by irregular stands.

The diploid variety 0156 X 133 had the highest gross sugar but it was not significantly better than ten other hybrids (Table 1). Differences for sucrose percentage were negligible for all hybrids in the test.

The 2n and 3n hybrids gave similar yields and were superior to the average of the 4n entries for gross sugar and tonnage (Table 2). The triploids had the highest impurity index mainly due to significantly higher potassium content.

Stands of the 3n and especially the 4n were poor in this test. In our experience, low germination and poor emergence are inherently characteristic of polyploids which makes it difficult to get a critical evaluation of the comparative performance of diploids versus polyploids. Poor stand undoubtedly influences tons per acre and may influence other characteristics since all varieties or levels of ploidy would not react the same with space.

A covariance adjustment with beet count was made in an effort to eliminate the variability due to stand. This adjustment did level out differences between the ploidy levels but not significantly (Table 3). The use of covariance might be questioned since beet count or stand is a characteristic of the treatments.

Table 1. POLYPLOID VARIETY TEST 4, NORTH FARM, LOGAN, UTAH, 1966

4 Reps, Randomized Blocks

25 Varieties

Variety code	Description	Acre yield		Percent sugar	Impurity index	PPM			Av. beets per plot
		Gross sugar	Tons beets			Amino N	Na	K	
24	0156(2n) X 133(2n)	8127	28.8	14.1	522	309	203	1428	41
07	0156(4n) X 133(2n)	7585	28.7	13.2	543	312	194	1341	37
05	0156(4n) X 0267(2n)	7410	26.5	14.0	457	221	139	1457	35
29	AI-10(2n) X 133(2n)	7388	25.0	14.8	547	390	135	1482	39
28	AI-1(2n) X 133(2n)	7348	26.7	13.8	636	422	225	1500	38
09	AI-12(2n) X 133(4n)	7125	26.3	13.5	683	361	186	1979	34
19	133(2n) X 0267(2n)	7094	26.1	13.6	457	266	165	1185	39
30	EL 32(2n) X 133(2n)	7021	25.2	13.9	570	419	275	1644	35
14	CT 9(2n) X 133(4n)	7001	25.6	13.7	590	333	155	1672	39
22	CT 9(2n) X 0267(2n)	6971	25.2	13.8	417	226	140	1186	39
23	128(2n) X 0267(2n)	6857	24.8	13.8	433	235	165	1212	40
20	129(2n) X 0267(2n)	6581	24.3	13.6	419	206	162	1218	40
27	CT 9(2n) X 133(2n)	6503	23.1	14.1	496	276	228	1373	32
13	129(2n) X 133(4n)	6495	23.2	14.0	568 ^c	318	172	1669	22
03	0156(4n) X 133(4n)	6494	23.1	14.0	491	249	202	1465	25
15	AI-1(2n) X 133(4n)	6397	23.1	13.9	590	336	187	1670	27
18	128(2n) X 133(4n)	6389	22.6	14.1	568 ^c	327	179	1584	26
21	0156(2n) X 0267(2n)	6388	23.1	13.8	414	229	146	1172	37
10	EL 31(2n) X 133(4n)	6216	21.5	14.5	603	443	240	1368	36
17	AI-10(2n) X 133(4n)	6078	21.3	14.4	578	375	161	1563	33
11	133(2n) X 0267(4n)	5753	20.8	13.8	526	284	249	1430	21
26	129(2n) X 133(2n)	5359	19.1	14.0	610	401	205	1514	23
02	0156(4n) X 0267(4n)	5201	19.3	13.4	474	214	156	1459	28
25	133(2n) X 133(2n)	4417	16.8	13.2	617	400	174	3198	32
04	133(4n) X 133(4n)	4079	14.7	13.9	664	441	345	1444	26
Mean		6491	23.4	13.9	539	320	192	1457	33
S. E. of Mean		487	1.68	0.34	42	38	20	104	2.69
Sig. Diff. 5%		1377	4.75	NS	119	107	57	294	08
Coefficient of Variation		15.0	14.3	4.93	15.5	23.8	21.0	14.4	23.4
Calculated 'F' Value		3.83	4.14	NS	3.55	4.10	5.77	3.26	5.37

Table 2. MEAN OF PLOIDY LEVELS TEST 2, LOGAN, UTAH, 1966

Unadjusted Means

Ploidy	Number entries	Gross sugar	T/A	Sucrose	Impurity index	N	Na	K	Beets
2n	12	6671	24.0	13.9	512	315	185	1360	36
3n	10	6645	24.0	13.9	571	331	204	1573	31
4n	3	5258	19.0	13.8	543	301	243	1456	26
Calculated 'F' Values		10.94**	5.48**	NS	5.48	NS	7.71**	12.96**	

Covariance Adjusted Means

Ploidy	Number entries	Gross sugar	T/A	Sucrose	Impurity index	N	Na	K	Beets
2n	12	6295	22.8	13.9	504	308	178	1340	36
3n	10	6869	24.8	14.1	575	335	186	1585	31
4n	3	6016	21.8	13.8	559	316	232	1495	26
Calculated 'F' Values		9.63**	10.92**	NS	8.29	NS	6.74	15.38**	

** Significant at the 1% level

Table 3. POLYPLOID VARIETY TEST 4, NORTH FARM, LOGAN, UTAH, 1966

Randomized Blocks

25 Varieties

Variety code	Description	Acre yield		Percent sugar	Impurity index	PPM			Av. Beets per plot
		Gross sugar	Tons beets			Amino N	Na	K	
03	0156(4n) X 133(4n)	7361	26.3	14.0	509	265	199	1509	26
02	0156(4n) X 0267(4n)	5770	21.4	13.4	486	226	155	1488	28
04	133(4n) X 133(4n)	4917	17.7	13.9	681	456	342	1487	26
	Mean (4n)	6016	21.8	13.8	559	316	232	1495	26
13	129(2n) X 133(4n)	7752	27.7	14.0	594	341	168	1734	22
18	128(2n) X 133(4n)	7197	25.6	14.2	577	342	177	1626	26
15	AI-1(2n) X 133(4n)	7145	25.8	13.9	605	350	185	1709	27
05	0156(4n) X 133(2n)	7141	25.6	14.0	452	217	140	1443	35
11	133(2n) X 133(4n)	7129	25.7	13.9	555	309	244	1501	21
07	0156(4n) X 133(2n)	7076	27.0	13.2	532	302	196	1315	37
09	AI-12(2n) X 133(4n)	7006	25.8	13.5	681	359	186	1973	34
14	CT 9(2n) X 133(4n)	6283	23.0	13.7	575	319	158	1636	39
17	AI-10(2n) X 133(4n)	6108	21.4	14.4	579	376	161	1565	33
10	EL 31(2n) X 133(4n)	5857	20.2	14.5	595	437	241	1350	36
	Mean (3n)	6869	24.8	14.1	575	335	186	1585	31
24	0156(2n) X 133(2n)	7170	25.4	14.1	503	291	206	1379	41
30	EL 32(2n) X 133(2n)	6812	24.4	13.9	566	416	276	1633	35
28	AI-1(2n) X 133(2n)	6780	24.7	13.8	625	411	227	1471	38
29	AI-10(2n) X 133(2n)	6700	22.6	14.8	533	378	137	1447	39
27	CT 9(2n) X 133(2n)	6653	23.6	14.1	499	279	228	1380	32
26	129(2n) X 133(2n)	6586	23.6	14.9	635	423	201	1577	23
19	133(2n) X 0267(2n)	6316	23.3	13.6	441	252	168	1146	39
22	CT 9(2n) X 0267(2n)	6283	22.7	13.8	403	213	143	1151	39
23	128(2n) X 0267(2n)	6050	22.0	13.8	516	220	168	1171	40
21	0156(2n) X 0267(2n)	5909	21.4	13.8	405	221	147	1148	37
20	129(2n) X 0267(2n)	5744	21.3	13.5	402	190	165	1175	40
25	133(2n) X 133(2n)	4537	17.2	13.2	619	402	174	1404	32
	Mean (2n)	6292	22.7	13.9	504	308	178	1340	36
	Mean	6491	23.4	13.9	539	320	192	1457	33
	S. E. of Mean	367	1.22	0.34	41	38	20	104	2.69
	Coeff. of Variation	11.32	10.49	4.96	15.40	23.68	21.18	14.27	23.4
	Sig. Diff. 5%	1039	3.45	NS	119	107	57	291	08
	Cal 'F' Value	4.21	4.69	1.13	3.55	4.22	5.15	3.22	5.37

TEST 5

The material in Test 5 was made up of hybrids of five CMS females (AI-1, AI-10, SLC 128, SLC 129, and 0156) and five inbred pollinators 712 (CT5 X CT8), 0461 (CT8 X line 289), 0523 (CT5mm), 0198 (129mm X American Crystal Nema Sel), and 030 (630= US 35/2aa X (US 35/2aa X Ovana) X CT8) making a total of 25 entries. The pollinators were selfed progeny of individual beets selected for high sugar. Data on each pollinator mother beet was as follows:

<u>Beet No.</u>	<u>Wt.</u>	<u>Sucrose</u>	<u>N</u>	<u>Na</u>	<u>K</u>	<u>Index</u>
0461-261	1114	17.2	115	37	960	214
0198-297	1000	17.4	268	39	1116	322
0523-146	1420	15.5	96	60	935	226
030-42	930	15.8	105	112	984	247
712-225	1110	17.0	96	78	1158	243

Means of the hybrids for the eight measurements are given in Table 1. Results clearly show there were significant differences between entries for all characteristics. Hybrid AI-1 X 712 had the highest gross sugar and significantly the highest yield in tons per acre. However, it was among the lowest in percent sucrose, and the poorest in quality as evidenced by the impurity index. Sucrose ranged from 14.02% to 15.96% with AI-1 X 0198 being the highest entry for this character. Hybrids AI-10 X 0198 and AI-10 X 0523 had low Na content; however, the former entry was high in N and K. AI-1 X 0523 and AI-10 X 0523 had the best quality as measured by the impurity index. These hybrids were among the low yielding entries in the test. Based upon all measurements, 0156 X 0198, would probably produce the best sugar yield.

Hybrids having 712 as a pollinator had the highest gross sugar and tons per acre, on the average (Table 2). Entries with the pollinator 030 were also high tonnage type. Pollinators 0461 and 0198 were highest in sucrose. The average of 0523 hybrids was lower in gross sugar and tonnage than the four other lines. No doubt the low beet count of 129 X 0523 and 128 X 0523 contributed to the low yield of these hybrids. They averaged second lowest in sucrose and best in quality as noted by the impurity index. "F" values for male and female groupings are given in Table 2A.

When hybrids were grouped by common female parent, the highest producing CMS parent was 0156 with a gross sugar of 8460 and 14.71% sucrose (Table 3). This parent also resulted in a low impurity index on the average. SLC 129 as a female parent produced the lowest gross sugar and tonnage on the average.

Table 1 Sugar Selection Hybrids Variety Test 5 Logan, Utah 1966

Variety code	Description	Acre Yield		Percent sugar	Impurity index	PPM			Av. Beets per plot
		Gross sugar	Tons beets			Amino N	Na	K	
24	AI-1 X 712	9402	33.30	14.30	513	239	221	1663	79
8	0156 X 0198	9135	29.38	15.55	385	242	118	1323	57
10	AI-10 X 0198	9113	28.44	15.96	453	332	95	1428	67
21	129 X 712	9097	31.30	14.43	445	221	146	1445	76
22	128 X 712	8806	29.90	14.65	383	199	119	1272	74
23	0156 X 712	8805	30.74	14.32	406	170	155	1412	74
17	128 X 030	8748	29.65	14.74	408	221	193	1228	72
18	0156 X 030	8746	29.86	14.74	404	184	188	1369	75
19	AI-1 X 030	8705	29.56	14.69	427	193	207	1402	78
16	129 X 030	8515	29.75	14.34	447	220	244	1316	75
20	AI-10 X 030	8427	27.63	15.29	385	198	130	1366	76
7	128 X 0198	8397	27.85	15.06	454	303	125	1380	65
25	AI-10 X 712	8367	28.68	14.65	404	180	110	1488	81
1	129 X 0461	8345	28.05	14.90	422	309	108	1152	77
3	0156 X 0461	8311	27.52	15.14	411	288	114	1168	79
2	128 X 0461	8206	27.85	14.74	463	360	121	1150	78
4	AI-1 X 0461	8199	28.43	14.42	437	262	167	1220	82
9	AI-1 X 0198	8003	27.35	14.65	501	305	130	1507	59
5	AI-10 X 0461	7924	26.45	14.99	465	361	102	1199	81
15	AI-10 X 0523	7696	25.14	15.25	363	193	92	1263	74
13	0156 X 0523	7303	26.08	14.02	380	175	150	1195	71
6	129 X 0198	7076	22.72	15.61	432	275	105	1433	44
14	AI-1 X 0523	6952	23.76	14.57	343	164	132	1133	72
11	129 X 0523	5542	18.97	14.52	380	183	112	1304	37
12	128 X 0523	5436	19.41	14.12	393	196	145	1224	38
Mean All Varieties		8130	27.51	14.79	420	239	141	1322	70
S. E. of Mean		314	1.06	0.14	20	6.3	12	34	3.0
Sig. Diff. 5%		888	2.98	0.40	57	18	34	96	8.0
Coef. Variation		9.08	9.19	2.29	11.75	25.56	20.12	6.24	1.05
Calculated F (Adj)		11.17	10.76	11.97	4.21	6.04	12.44	15.56	18.64

Table 2 Sugar Selection Hybrids Grouped by Maleparent Variety Test 5 Logan, Utah 1966

Variety code	Description	Acre Yield		Percent sugar	Impurity index	PPM			Av. Beets per plot
		Gross sugar	Tons beets			Amino N	Na	K	
1	129 X 0461	8345	28.05	14.90	422	309	108	1152	77
2	128 X 0461	8206	27.85	14.74	463	360	121	1150	78
3	0156 X 0461	8311	27.52	15.14	411	288	114	1168	79
4	AI-1 X 0461	8199	28.43	14.42	437	262	167	1220	82
5	AI-10 X 0461	7924	26.45	14.99	465	361	102	1199	81
	Mean	8197	27.66	14.84	440	316	122	1178	79
6	129 X 0198	7076	22.72	15.61	432	275	105	1433	44
7	128 X 0198	8397	27.85	15.06	454	303	125	1380	65
8	0156 X 0198	9135	29.38	15.55	385	242	118	1323	57
9	AI-1 X 0198	8003	27.35	14.65	501	305	130	1507	59
10	AI-10 X 0198	9113	28.44	15.96	453	332	95	1428	67
	Mean	8345	27.15	15.37	445	291	115	1414	58
11	129 X 0523	5542	18.97	14.52	380	183	112	1304	37
12	128 X 0523	5436	19.41	14.12	393	196	145	1224	38
13	0156 X 0523	7303	26.08	14.02	380	175	150	1195	71
14	AI-1 X 0523	6952	23.76	14.57	343	164	132	1133	72
15	AI-10 X 0523	7696	25.14	15.25	363	193	92	1263	74
	Mean	6586	22.67	14.50	372	182	126	1224	58
16	129 X 030	8515	29.75	14.34	447	220	244	1316	75
17	128 X 030	8748	29.65	14.74	408	221	193	1228	72
18	0156 X 030	8746	29.86	14.74	404	184	188	1369	75
19	AI-1 X 030	8705	29.56	14.69	427	193	207	1402	78
20	AI-10 X 030	8427	27.63	15.29	385	198	130	1366	76
	Mean	8635	29.29	14.76	414	203	192	1336	75

(Continued on page 164)

Table 2 (continued)

Variety code	Description	Acre Yield		Percent sugar	Impurity index	PPM			Av. Beets per plot
		Gross sugar	Tons beets			Amino N	Na	K	
21	129 X 712	9097	31.30	14.43	445	221	146	1445	76
22	128 X 712	8806	29.90	14.65	383	199	119	1272	74
23	0156 X 712	8805	30.74	14.32	406	170	155	1412	74
24	AI-1 X 712	9402	33.30	14.30	513	239	221	1663	79
25	AI-10 X 712	8367	28.68	14.65	404	180	110	1488	81
	Mean	8895	30.78	14.47	430	202	150	1456	77
	Mean All Varieties	8130	27.51	14.78	420	239	141	1322	70
	S. E. of Mean	314	1.06	0.14	20	6.3	12	34	3.0
	Sig. Diff. 5%	888	2.98	0.40	57	18	34	96	8.0
	Coef. Variation	9.08	9.19	2.29	11.75	25.56	20.12	6.24	1.05
	Calculated F (Adj)	11.17	10.76	11.97	4.21	6.04	12.44	15.56	18.64

Table 2A Calculated F Values Sugar Selection Hybrids Test 5 Logan, Utah 1966

Source of Variation	DF	Acre Yield		Percent sugar	Impurity index	PPM			Av. Beets per plot
		Gross sugar	Tons beets			Amino N	Na	K	
Females	4	4.96	5.12	14.62	1.97	2.49	15.87	8.70	18.92
Males	4	44.38	41.53	21.22	11.86	30.47	23.43	58.20	61.06
Females X Males	16	4.31	3.62	3.66	2.46	NS	4.24	4.48	7.90

Significant F Values

For Males and Females 5% = 2.46 1% = 3.51
For Males X Females 5% = 1.75 1% = 2.19

Table 3 Sugar Selection Hybrids Grouped by Female Parent Variety Test 5 Logan, Utah 1966

Variety code	Description	Acre Yield		Percent sugar	Impurity index	Parts Per Million				Av. Beets per plot
		Gross sugar	Tons beets			Amino				
						N	Na	K		
1	129 X 0461	8345	28.05	14.90	422	309	108	1152	77	
6	129 X 0198	7076	22.72	15.61	432	275	105	1433	44	
11	129 X 0523	5542	18.97	14.52	380	183	112	1304	37	
16	129 X 030	8515	29.75	14.34	447	220	244	1316	75	
21	129 X 712	9097	31.30	14.43	445	221	146	1445	76	
	Mean	7715	26.16	14.76	425	242	143	1330	62	
2	128 X 0461	8206	27.85	14.74	463	360	121	1150	78	
7	128 X 0198	8397	27.85	15.06	454	303	125	1380	65	
12	128 X 0523	5436	19.41	14.12	393	196	145	1224	38	
17	128 X 030	8748	29.65	14.74	408	221	193	1228	72	
22	128 X 712	8806	29.90	14.65	383	199	119	1272	74	
	Mean	7938	27.93	14.66	442	256	141	1251	65	
3	0156 X 0461	8311	27.52	15.14	411	288	114	1168	79	
8	0156 X 0198	9135	29.38	15.55	385	242	118	1323	57	
13	0156 X 0523	7303	26.08	14.02	380	175	150	1195	71	
18	0156 X 030	8746	29.86	14.74	404	184	188	1369	75	
23	0156 X 712	8805	30.74	14.32	406	170	155	1412	74	
	Mean	8460	28.72	14.75	397	212	145	1293	71	
4	AI-1 X 0461	8199	28.43	14.42	437	262	167	1220	82	
9	AI-1 X 0198	8003	27.35	14.65	501	305	130	1507	59	
14	AI-1 X 0523	6952	23.76	14.57	343	164	132	1133	72	
19	AI-1 X 030	8705	29.56	14.69	427	193	207	1402	78	
24	AI-1 X 712	9402	33.30	14.30	513	239	221	1663	79	
	Mean	8252	28.48	14.53	444	233	171	1385	74	

(Continued on page 166)

Table 3 (Continued)

Variety code	Description	Acre Yield		Percent sugar	Impurity index	Parts Per Million			Av. Beets per plot
		Gross sugar	Tons beets			Amino N	Na	K	
5	AI-10 X 0461	7924	26.45	14.99	465	361	102	1199	81
10	AI-10 X 0198	9113	28.44	15.96	453	332	95	1428	67
15	AI-10 X 0523	7696	25.14	15.25	363	193	92	1263	74
20	AI-10 X 030	8427	27.63	15.29	385	198	130	1366	76
25	AI-10 X 712	8367	28.68	14.65	404	180	110	1488	81
	Mean	8305	27.27	15.23	414	253	106	1349	76
	Mean All Varieties	8130	27.51	14.78	420	239	141	1322	70
	S. E. of Mean	314	1.06	0.14	20	6.3	12	34	3.0
	Sig. Diff. 5%	888	2.98	0.40	57	18	34	96	8.0
	Coef. Variation	9.08	9.19	2.29	11.75	25.56	20.12	6.24	1.05
	Calculated F (Adj)	11.17	10.76	11.97	4.21	6.04	12.44	15.56	18.64

STUDIES ON SEMI-MALE STERILITY IN SUGAR BEETS

by J. C. Theurer

A partial fertile plant of 9136 (SL 7121 X SLC 03) was selected in 1964 for study of the genetic behavior of semi-male sterility. Segregation observed in the F_1 , F_2 , and b_1 generations was presented in the 1965 Research Report.

Seven male sterile F_2 segregates were crossed to the annual pollinator SLC 03, and fertility readings were made on each plant by microscopic observation of aceto-carmin stained pollen. Anthers from newly opened flowers on each plant were examined at various intervals, until all flowers on the plant were open. The original data showed significant differences between crosses, even though all male sterile parents were phenotypically identical.

In an effort to note aging effect and/or environmental stability of CMS, seedstalks were cut off and new shoots were allowed to develop in the greenhouse at 70 to 80 F. At anthesis each plant was carefully examined and a fertility reading made on the basis of a random collection of anthers. This procedure was repeated throughout the year resulting in six to twelve readings on each plant.

Hybrids of four F_2 male sterile segregates from the original parent crossed to the biennial pollinator SLC 129 and five fertile or partial-fertile segregates that were self pollinated were evaluated for fertility this past year also. F_1 and selfed seed was planted in 4-inch clay pots in the greenhouse. When plants were eight weeks old, they were photo-thermally induced and later returned to the greenhouse for observation. Microscopic fertility readings were made at weekly intervals on this material.

Results and Discussion

Variation in fertility for the seven annual CMS hybrids is shown in Table 1. No plants that were scored as fertile or partial-fertile in the first reading gave similar successive readings. The plants either tended to vary from male sterile to partial fertiles, or they appeared to remain male sterile after the first reading. In one line (5931), seven plants which appeared male sterile during the first, and many subsequent readings produced a small amount of stainable pollen at one reading. However, plants originally scored male sterile tended to remain such throughout the year.

The data indicate both genetic and micro-environmental differences occur in these seven male sterile hybrids.

The male sterile X SLC 129 crosses gave all male sterile offspring with five exceptions (Table 2). The fourth reading on these five plants, made August 2, 1966, showed 10-20% stainable pollen. Subsequently these plants were read as male sterile.

The selfed progeny showed a tendency toward male sterility in that many plants were consistently read as male sterile and no plant showed an abundance of stainable pollen at subsequent readings. Plants that showed partial fertility had mainly 5-10% stainable pollen; however, a few were as high as 50% fertile at the August 2 reading. No correlation between the fertility of the parent and offspring was apparent. Line 5912 showed the greatest trend for fertility, but 5930 derived from another 50% fertile plant had more male sterile offspring than did 5906, a 20% fertile parent.

The trend for higher fertility during the August 2 reading might be attributed to either a higher temperature, or to the addition of fertilizer to the soil a short time previous to the reading. Plans are to further investigate light, temperature, and soil nutrient effects upon partial fertile plants.

Table 1. Variation in fertility readings of crosses between male sterile segregates from the semi-male sterile line 9136 and the O-type annual pollinator, SIC 03

Line no.	MS	First reading PF	Y	Total number plants	Fertility based on average of 6 to 12 readings per plant					
					Always MS	MS-First some PF later	PF-F first MS thereafter	PF-F first variable MS to PF	Always PF-F	
	(no.)	(no.)	(no.)		(no.)	(no.)	(no.)	(no.)	(no.)	
5913	32	4	0	36	32	0	4	0	0	
5921	0	5	0	5	0	0	0	5	0	
5924	16	8	3	27	16	0	3	8	0	
5931	22	70	2	94	15	7	29	43	0	
5933	36	1	0	37	36	0	1	0	0	
5936	0	5	6	11	0	0	5	6	0	
5937	3	2	1	6	3	0	3	0	0	
Total	109	95	12	216	102	7	45	62	0	

Table 2. Pollen fertility readings of selfed progenies, and crosses of male sterile segregates from 9136 and the biennial O-type pollinator, SLC 129

Current number	Parent Material	Number Lines	Always MS	MS-PF	Always PF
5905	Male Sterile X SLC 129	2	17	5	0
5914	Male Sterile X SLC 129	1	89	0	0
5917	Male Sterile X SLC 129	1	15	0	0
5918	Male Sterile X SLC 129	1	6	0	0
5906	PF 20% Stainable Pollen	6	34	10	0
5912	PF 50% Stainable Pollen	10	42	27	0
5929	PF 35% Stainable Pollen	1	1	1	0
5930	PF 50% Stainable Pollen	5	18	5	0
5932	PF 50% Stainable Pollen	6	26	6	0

Asexual Transmission of Cytoplasmic Male Sterility

by J. C. Theurer and E. H. Ottley

Studies of the possible graft transmission of cytoplasmic male sterility (CMS) were continued in 1966. Materials and methods have been given in previous Research Reports.

Additional lines of the male-sterile segregates, involving CT 5 and SLC 129 grafts crossed to SLC 03, were observed.

A sample of G_2 grafted progenies from populations M3579-5, 94414, 94602.1, 94625, SLC 03, and SLC 03 CMS were also classified for fertility.

Results

CT 5 and SLC 129 crosses and backcrosses

A summary of the fertility of F_1 , F_2 , b_1 , and b_2 generations, including the data presented in 1965, are shown in Table 1. Eight F_1 lines of CT 5 male sterile segregates in the G_1 crossed to SLC 03 gave 100% fertile offspring, with all plants having better than 70% aceto-carmin-stained pollen. Seven F_1 sister lines segregated mostly male-sterile offspring, with fertile plants ranging from 5%-90% stainable pollen. The ratio of male-sterile to fertile plants for one F_2 line, [(CT 5/1114)] X 03, gave a good fit ($P=.3-.5$) to a 3:1 ratio as expected for Mendelian male sterility. Segregation of two other F_2 lines did not fit a 3:1 ratio. Chi square of the combined F_2 lines resulted in a P value of .02-.05. All of the b_1 and b_2 lines studied had a majority of male-sterile progeny with a marked decrease in the range and average fertility from the b_1 to the b_2 .

With the exception of a single plant, all of the male-sterile segregates from SLC 129 population grafts crossed to SLC 03 produced fertile offspring. The single exception could be explained by misclassification due to environmental effects.

It is doubtful that environment alone accounts for the large number of male-sterile segregates in CT 5 graft populations. The data indicate transmission of CMS across the graft union or alternatively one or all of the following: (1) new mutations for CMS occurred, (2) the Mendelian male sterility, known to be carried by the parent line is not inherited as a single recessive gene, (3) the parental line carries CMS plasm and is segregating for pollen restorer genes.

In an attempt to further clarify the segregation in CT 5 graft X SLC 03 progenies, crosses were made with ungrafted parental CT 5 Mendelian male-sterile plants and SLC 03. Results to date, although incomplete, are shown in Table 2. These preliminary data indicate that the

Table 1. Fertility of male-sterile segregates from CT 5 and SLC 129 grafts crossed with the annual O-type pollinator SLC 03.

Scion Stock	X Pollinator	Gen.	No. lines	No. plants		% Fertility ^{1/}	
				MS	F.	Range	Av.
$\frac{CT\ 5}{1114}$	X 03	G_1F_1	5	0	22	70-99	90
			2	57	3	5-50	63
		G_1F_2	1	5	22	10-90	59
		G_1b_1	1	10	3	5-40	17
		G_1b_2	1	25	0	-----	--
$\frac{CT\ 5}{1122}$	X 03	G_1F_1	1	0	2	98-99	99
			1	9	0	-----	--
		G_1F_2	1	15	29	20-90	76
		G_1b_1	2	60	12	20-80	38
$\frac{CT\ 5}{1124}$	X 03	G_1F_1	2	0	30	50-90	90
			4	22	9	80-90	89
		G_1F_2	1	9	3	10	10
		G_1b_1	5	104	30	10-90	41
		G_1b_2	2	29	8	10-50	24
$\frac{129}{1114}$	X 03	G_1F_1	3	0	39	90-99	95
$\frac{129}{1122}$	X 03	G_1F_1	7	1	91	70-90	89
$\frac{129}{1124}$	X 03	G_1F_1	1	0	16	20-90	85

^{1/} Range and average of fertile segregates based on percent aceto-carminc-stained pollen.

Table 2. Fertility of CT 5 (0223) ungrafted male-sterile plants
X SLC 03.

Cross no.	MS	No. plants		% Fertility ^{1/}	
		PF	F	Range	Av.
G 6300	0	0	2	90	90
G 6301	0	0	71	80-90	89
G 6302	0	0	18	90	90
G 6303	0	2	86	40-90	88
G 6304	0	0	3	90	90
G 6305	0	0	1	90	90
G 6306	0	3	66	40-90	86
G 6308	0	0	4	90	90
G 6309	0	0	13	70-90	88

^{1/} Fertility range and average based upon percent aceto-carminestained pollen.

sterility of the parental line is indeed of the Mendelian type.

New grafts and crosses between CT 5 and CMS lines are in progress to further verify the results noted above and/or to eliminate some of the alternatives for the noted male-sterile segregation.

1963-64 grafts in the G₂ generation

The comparative results of G₀, G₁ and G₂ grafted progenies are shown in Table 3. Lines 94414 and 94602.1 on SLC 03 CMS again had several male-sterile segregates, while M 3579, 94625, and SLC 03 had a few male steriles in the G₂. Grafts of fertile on fertile (94625 on SLC 03; and SLC 03 on SLC 03) remained autonomous for fertility.

Population 94602.1 is known to carry the Mendelian male-sterile gene (a_1), which probably accounts for segregation in the G₂. Crosses have been made of 94414 male-sterile segregates and SLC 03 and will be evaluated next year to discern whether or not this population is heterozygous A_1a_1 .

The limited number of male-sterile plants in the G₂ of other populations could be due to a low frequency of CMS transmission, mutation, or environmental effects which resulted in our misclassification of these plants.

Table 3. Fertility of G₀, G₁, and G₂ generation seedling grafts made in 1963-64.

Scion on stock	Gen.	No. lines	No. plants		% Fertility	
			MS	F.	Range	Avg.
94414 on 03 CMS	G ₀	--	1	17	20-90	77
	G ₁	16	194	327	5-98	53
	G ₂	9	19	66	10-90	66
94602.1 on 03 CMS	G ₀	--	0	30	20-90	77
	G ₁	25	10	614	10-99	75
	G ₂	17	3	384	5-90	71
	G ₃	7	13	150	10-90	62
M 3579 on 03 CMS	G ₀	--	0	39	60-90	88
	G ₁	4	0	91	10-98	88
	G ₂	8	6	134	5-90	52
94625 on 03 CMS	G ₀	--	0	9	90	90
	G ₁	8	0	263	30-98	86
	G ₂	8	4	295	10-99	83
03 on 03 CMS	G ₀		0	47	20-90	85
	G ₁	45	2	1256	10-90	78
92.592.1 on 03 CMS	G ₀	--	0	21	90	90
94625 on 03	G ₀	--	0	2	90	90
	G ₁	2	0	44	70-98	88
	G ₂	2	0	58	10-90	79
03 on 03	G ₀	--	0	34	70-90	87
	G ₁	11	0	359	30-99	81
03 CMS on 03	G ₀	--	15	0	-----	--

Segregation of Pollen Fertility in Restorer Hybrids

by J. C. Theurer and E. H. Ottley

Nineteen cytoplasmic male-sterile (CMS) lines and two Mendelian male-sterile lines were crossed with a pollen restorer inbred in 1964. The fertility of the F_1 progenies was observed and findings reported in 1965 Research Reports. Four of these F_1 hybrids, 12 F_2 , and five b_1 progenies were planted in the field at St. George, Utah, in the fall of 1965 and visual pollen fertility readings were made on the progenies in May and June, 1966.

In addition, three F_1 restorer hybrid progenies were photothermally induced and allowed to flower in the greenhouse at 70° F. Pollen dehiscence was noted on each plant and a sample of pollen and/or anthers was collected for microscopic observation. Fertility was determined on the basis of the percent aceto-carmin-stained pollen.

Results

All plants in the four F_1 progenies grown at St. George produced abundant pollen with the exception of six plants in population R 4136 (Table 1). These exceptions were partial fertile and showed poor dehiscence. R 4136, a hybrid of NB-1 CMS and the pollen restorer inbred, gave the greatest number of partial male-sterile progeny in the 1965 readings also (see 1965 Research Report page 135).

A definite trend was noted in the F_2 , even though the segregation ratios were variable. Every hybrid segregated more male-fertile (pollen-producing plants) than male-sterile offspring.

In the b_1 generation all hybrids had a segregation of more male-sterile than fertile progeny.

The results of the F_2 and b_1 segregations indicate that pollen restoration is governed by two or more genes having complementary effects. Inasmuch as there was a slight amount of contamination due to volunteer beets in the field at St. George, there may be some error in the ratios obtained. However, this error was not great enough to explain the poor fit of a two-complimentary gene hypothesis to much of the data.

Careful observation in the greenhouse on three F_1 restorer hybrids revealed that there is a marked difference in CMS lines (Table 2). Data confirmed previous field results which indicated NB-1 CMS was a more superior emasculator than SLC 129 CMS or other SLC CMS material.

Plans are under way to further study the inheritance of these differences in CMS lines.

Table 1. Pollen fertility of F_1 , F_2 , and b_1 generation restorer hybrids determined in St. George field planting, 1966.

Current no.	Description	Gen.	No. families	No. plants $\frac{1}{F}$	
				MS	F
R 4131	SLC 129 CMS X R_f	F_1	--	0	130
R 4135	CT 9 X CMS X R_f	F_1	--	0	102
R 4136	NB-1 CMS X R_f	F_1	--	0	131
R 4145	2938 CMS X R_f	F_1	--	0	191
R 5503	SLC 129 CMS X R_f	F_2	20	643	915
R 509	CT 9 CMS X R_f	F_2 (O.P.)	1	19	46
R 5508	NB-1 CMS X R_f	F_2	9	163	428
R 5515	2938 CMS X R_f	F_2	9	129	438
R 5510	308H01 X R_f	F_2	5	72	275
R 5511	211H3 X R_f	F_2	2	40	62
R 5512	S 3317-5 X R_f	F_2	6	61	351
R 5513	S 3317-14 X R_f	F_2	1	25	54
R 5514	2937 X R_f	F_2	10	70	565
R 528	SLC 128 CMS X R_f	F_2 (O.P.)	1	24	32
R 5506	AI-1 CMS X R_f	F_2	1	15	65
R 503	F.C 503 CMS X R_f	F_2 (O.P.)	1	35	102
R 5109	SLC 129 CMS X R_f	b_1	1	186	56
R 5113	CT 9 CMS X R_f	b_1	1	105	49
R 5114	SLC 128 CMS X R_f	b_1	1	21	6
R 5111	AI-1 CMS X R_f	b_1	1	231	88
R 5112	C 515 CMS X R_f	b_1	1	133	92

$\frac{1}{F}$ Visual observation in which MS = white-anther plants and F = yellow anthers with varied degrees of pollen dehiscence.

Table 2. Fertility of F₁ restorer hybrids grown in the greenhouse at Logan, Utah, 1966.

Current no.	Description	No. plants by upper class limits (% fertile) $\frac{1}{2}$										Total no. plants	Av. % fertility	
		MS	T $\frac{1}{2}$	10	20	30	40	50	60	70	80			90
R 4131	SLC 129 CMS X R _f	0	0	0	0	1	0	0	4	4	4	28	41	83
R 4135	CT a CMS X R _f	0	0	0	3	1	1	1	0	2	7	37	52	81
R 4136	NB-1 CMS X R _f	6	25	39	10	0	6	1	1	1	2	0	93	14

$\frac{1}{2}$ Fertility determined by percent aceto-carmin-stained pollen at anthesis of flowers on main stem of seed stalk.

$\frac{2}{2}$ T = trace, 1 or 2 stainable pollen grains per thousand.

Photosynthesis and Respiration Rate Studies with Sugar Beets

II. The effect of previous light exposure on rates as measured by CO₂ exchange

by Myron Stout

INTRODUCTION

In a previous study (4) with sugar beet half-leaves that were exposed to light or darkness before testing, it was found that respiration rate and dry weight increased rapidly after only a few minutes exposure to light. The respiration rate of leaves previously kept in darkness for 16 hours increased nearly 20% after only five minutes exposure to sunlight. Photosynthesis, as measured by increase in dry weight per unit of leaf area, was nearly linear or relatively constant in rate. The apparent difference in rates of the two related processes as measured by different methods prompted a study of the time factor in the attainment of equilibrium rates as measured by changes in the CO₂ economy of plants. Some of the sources of variation in measurements between different plants or the same plants on different days might be traceable to a lack of equilibrium conditions when the measurements are made.

MATERIALS AND METHODS

Three similar plants of the phenotypically uniform F₁ hybrid variety 4162 were used in the present studies. They were grown in 5-quart plastic pots containing a mixture of vermiculite and sponge-rock and watered with half strength Hoagland solution. The growth chamber had a light intensity of 2,700 F. C. at leaf height and 4,000 F. C. at leaf height when pots were placed on a pedestal above the bench and near the ceiling of the growth chamber. Temperature of the growth chamber was 25° C daytime and 18° C at night. Day length was from 4:00 A.M. to 6:00 P.M. All plants were preconditioned in the growth chamber at the stated illumination intensity for at least six hours before testing. Plants kept in darkness were covered by large cardboard boxes and prepared for testing in dim light. All rates were measured at 25° C and 300 ppm CO₂ concentration. The pots were sealed in plastic bags and tightly tied around the crown of the root before testing. The leaves were held horizontally at crown height, without overlapping of leaves, by small wires fastened to a supporting screen as previously described (3). Light intensity was 3877 foot candles at leaf level. The light, from five reflector flood lamps, passed through 2 3/8 inches of rapidly circulating distilled water before reaching the plants. Water-bath temperature was regulated to 25 ± .02° C in all tests. Actual leaf temperature was not measured but air within the chamber was rapidly circulated over the leaves and against the five cooling walls of the chamber. Respiration rates reported in the figures were run after the photosynthesis rate measurements were made. A separate set of respira-

tion rate measurements were run on the same plants; first, following a 16 hour period of darkness, then after a one hour period of exposure to 3877 foot candles of illumination. These data are reported in the text. All data are reported in milligrams of CO_2 per square decimeter of total leaf area per hour.

RESULTS

By using each of the plants three times at each preconditioning light exposure, it was possible to reduce plant variation to a low level. The data in Figures 1, 2, and 3 are, therefore, the average values of nine series of measurements. All photosynthesis rate curves were characteristically sigmoid.

The data in Figure 1 show that plants previously kept in darkness for 16 hours before illumination took up little or no CO_2 from the atmosphere for several minutes after the lights were turned on. In fact, some of them gave off more CO_2 than they absorbed. After about ten minutes the rate of CO_2 uptake increased rapidly. The rate of increase declined after about 20 minutes. A semi-plateau was reached about 60 minutes after lights were turned on, however, the rate increased slowly up to 120 minutes.

Sugar beets previously illuminated at 2,700 F. C. had a higher rate of CO_2 uptake at the start of the test period. The rate increased more slowly and reached a lower level at the end of two hours. Those previously illuminated at 4,000 foot candles initially had an even higher rate of CO_2 uptake but increased more slowly. The increase in CO_2 uptake was greater at the end of two hours than either of the other preconditioning treatments, indicating that all treatments might reach the same level after three or four hours. The photosynthesis tests were discontinued at the end of two hours. At this time the lights were turned off, the chamber was covered, and respiration rates were determined.

The data in Figure 2 show the calculated rates of total photosynthesis (net accumulation + respiration). The curves are similar in form but higher than those of net accumulation.

The data in the upper part of Figure 3 show the rates of respiration after two hours of light at 3,877 foot candles intensity. The lower part of Figure 3 shows the relationship between net accumulation and respiration rates. The curves are similar to those in Figures 1 and 2 but were more closely spaced at the end of two hours. This is due to differences in respiration rate.

A separate set of experiments were run with the same plants, in which all plants were held in darkness for 16 hours. Respiration rate was run before exposure to light and following a one hour photosynthetic period. The average respiration rate when measured after a long period of darkness was $4.31 \text{ mg CO}_2/\text{dm}^2/\text{hr.}$ After one hour at 3,877 foot candles of light exposure the rate was $6.97 \text{ mg CO}_2/\text{dm}^2/\text{hr.}$, or an increase of 61.9%.

DISCUSSION

The data indicate rather wide differences in photosynthetic and respiratory rates of sugar beets depending on the environment of the plants before the measurements were made. These differences were large in magnitude for several minutes during the first part of the test periods. In these tests the rates were almost the same for all pre-treatments 20 minutes from the start of the tests, but were far below the maximum rates attained after one or two hours.

Although photosynthesis and respiration rates have been studied for many years, critical measurements between different treatments of plants or varieties of the same species have received little attention. In most instances measurements are made after a relatively short exposure of the plant to the experimental environment. The present data indicates that rather wide differences may be expected with only small differences in time before the measurements are made.

In measuring rates of photosynthesis and respiration by means of gaseous exchange at least two important factors must be considered when the plants are suddenly changed from light to darkness or the reverse; 1. effect of the change on stomatal response and, 2. reversibility of equilibria in the metabolic sequence involved in both processes.

Within reasonable limits of temperature and water availability that have overriding effects on stomatal response, the evidence is strong that stomatal response is largely controlled by CO_2 concentration within the stomatal cavity (1) (2). Under usual conditions stomata open in light and close in darkness.

If one considers the many equilibria involved in the metabolic processes of photosynthesis and respiration and the shifts in concentration of one metabolite over another in order to reverse the direction of the overall process, the time lag in the establishment of a uniform rate can be visualized. Under equilibrium conditions of a uniform rate any one of the many steps involved may become the "bottle neck" controlling the overall rate.

The stomata of a plant respiring normally in darkness would be closed due to the high concentration of CO_2 in the tissues. Each step in the metabolic chain is moving toward the production of CO_2 from sugar, with a higher concentration of the reduced metabolite than the more oxidized one. As light energy strikes the leaf, CO_2 in the tissues as gaseous CO_2 is first metabolized. The light energy also causes a slight increase in temperature that expands gaseous CO_2 and releases some dissolved CO_2 with the increased transpiration. Organic acids, in the process of being oxidized, must again be reduced before any great need for exogenous CO_2 is necessary. As the endogenous supply is used up the rate of CO_2 uptake from the atmosphere increases rapidly because concentration gradients of the metabolic pools along the metabolic chain are receptive to reduced substrates. As concentration gradient resistance builds up along the metabolic pathway, the rate of increase in CO_2

uptake slows down until translocation of sugars might also affect the rate of CO₂ uptake.

Conversely, the stomata of a plant photosynthesizing rapidly under high light intensity would be open. The concentration gradients along the metabolic chain would be higher in the more oxidized substrates than the more highly reduced ones. As the plant is suddenly darkened CO₂ is rapidly released from metastable compounds at high concentration gradients at the oxidized end of the metabolic chain. The stomata begin closing as CO₂ is released. The concentration gradients farther up the metabolic chain are reversed until translocation of sugars to the metabolic site may become a limiting factor in the overall respiratory rate.

Such an explanation would seem to be adequate to explain changes in rates of uptake or evolution of CO₂ in photosynthesis or respiration of plants under normal environmental conditions.

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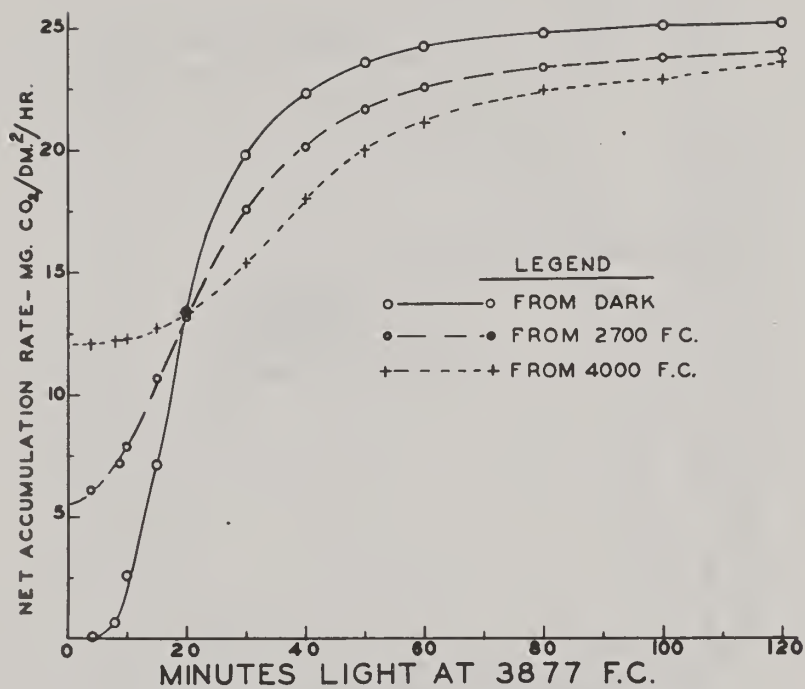


Figure 1. Effect of previous light exposure on net accumulation rate of CO₂ by sugar beet leaves at 300 ppm CO₂, 25° C and 3877 F. C. illumination

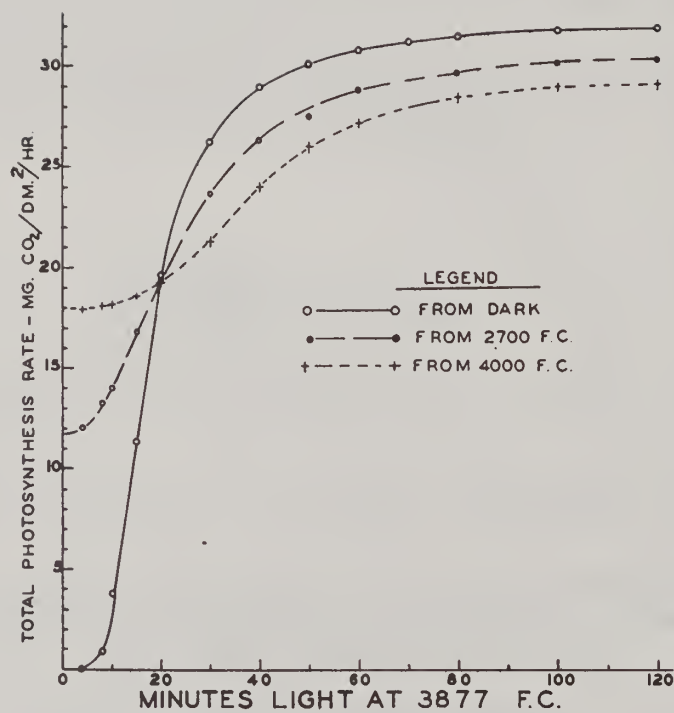


Figure 2. Effect of previous light exposure on total photosynthesis rate by sugar beet leaves 300 ppm CO₂, 25° C and 3877 illumination

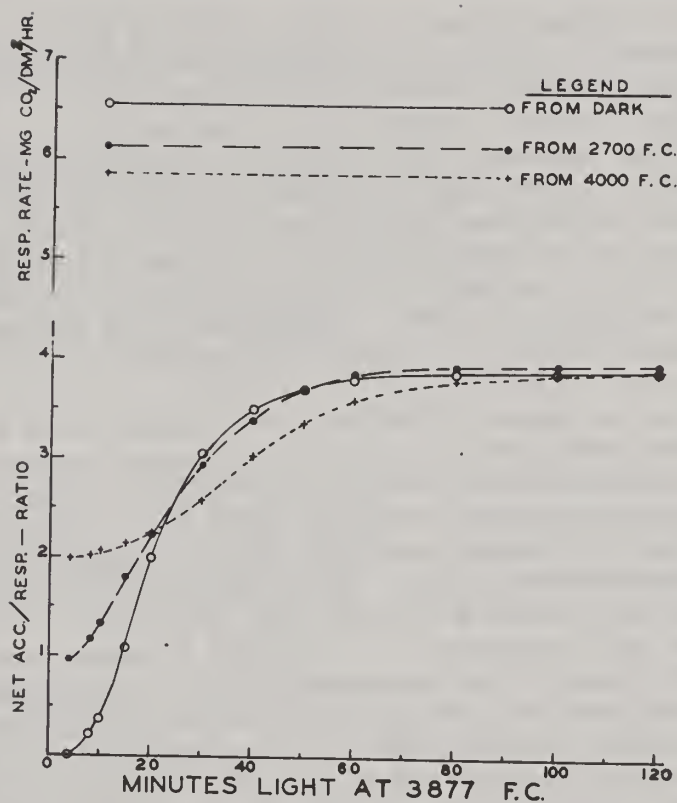


Figure 3. (upper) Effect of previous light exposure on respiration rate of sugar beet leaves following a 2-hour photosynthesis test

(lower) Effect of previous light exposure on net accumulation - respiration ratio of sugar beet leaves

Physiological Studies
by Myron Stout

Photosynthesis and Respiration Rate Studies
Improvements in Equipment and Methods

Several improvements have been made in the equipment and methods of measuring changes in the CO_2 uptake or output of sugarbeets since the last foundation report was written. Two of these changes will be described.

1. The gas drying column has been replaced with a moisture condensing unit that insures a low and constant moisture content of the air to the CO_2 analyzer. The water-vapor error is equivalent to less than 3 ppm of CO_2 and is maintained constant by having the condensing coil in a bath of distilled water-ice mixture. This greatly reduces mixing of air to the analyzer and gives an immediate response of the analyzer to changes in CO_2 concentration within the large photosynthesis-respiration chamber. The whole system can be restandardized each time a measured amount of CO_2 is introduced into the system. Successive restandardizations can be made well within an accuracy of $\pm 2\%$. A paper has been approved for publication in the Journal of the A.S.S.B.T. on equipment and methods.

2. Previous attempts to relate virus infection to photosynthetic or respiratory rates were unsuccessful due to several sources of variation (1964 report). The previous studies were run at a normal 300 ppm of CO_2 and at relatively high light intensity (3877 F.C.). Recent studies have been made in which the light intensity and CO_2 concentration during consecutive measurements was varied. Tests were run for more than an hour at low light intensity (736 F.C.) and high CO_2 concentration (445 ppm CO_2). In this case the Hill reaction or photolysis of water should be rate-limiting with the plant in an abundance of CO_2 . Following the measurement of the respiration rate at the same CO_2 concentration, the light intensity was increased to 3800 F.C. and the CO_2 concentration decreased to 130 ppm. Successive rate measurements were run at the low CO_2 concentration and high light intensity for at least an hour, then the respiration rate was determined at the low CO_2 concentration. This change in environment should result in a high Hill reaction rate and make CO_2 uptake rate-limiting in the overall photosynthetic process.

Recent studies of curly-top infected and virus-free sugarbeets have shown that the net accumulation rate values of infected plants decline at both high light intensity and low CO_2 and at low light intensity and high CO_2 concentration following infection.

The rate of decline after infection was more rapid for the first three weeks after infection when measured under low light intensity and high CO_2 concentration (Hill reaction rate-limiting). However, at the end of 50 days following infection, the decline was greater when the measurements were made at high light intensity and low CO_2 concentration (dark reaction rate-limiting). Although the data from the 1964 tests were not sufficiently consistent to warrant publication, the recent tests confirmed the general trends evident in the earlier studies. A new series of tests are being run prior to publication.

Two other studies run previously will be repeated using the more discriminating technique described.

GREENHOUSE TESTS OF CURLY TOP RESISTANCE AT LOGAN, UTAH

C. L. Schneider and D. L. Mumford

In 1966, 247 breeders' seed lots were tested in the greenhouse for curly top resistance at the Logan Station. Included were 40 lots from J. O. Gaskill; Fort Collins, Colorado, and 207 lines from J. C. Theurer; Logan, Utah.

The inoculation tests were conducted as previously described^{1/}. There were a series of 28 inoculation tests, planted about 5 days apart. Each test usually comprised 9 seed lots to be evaluated plus check variety US 41, included as a basis for comparison.

There were five 6-inch pots, each containing 4 seedlings, of each entry. Seedlings in a growth chamber maintained at 27 degrees C. were exposed for 5-7 days to caged viruliferous beet leafhoppers (2 per plant) that had previously fed on sugarbeet plants infected with curly top virus isolate A-1-A. After the insects were removed, plants were moved to the greenhouse.

About 6 weeks after inoculation, each plant was numerically graded according to degree of curly top reaction. Curly top grades ranged from 1 (symptoms very light) to 9 (plant dead). Plants with no symptoms were excluded from computation of average curly top severity grade because of the possibility that they might have escaped infection without being immune.

Apparently there were differences in degree of curly top exposure between tests, as indicated by differences in curly top incidence and severity in check variety US 41 in different tests. Incidence ranged from 31 to 100% and severity grades from 4.5 to 7.5 (Table 1). It is conjectured that differences in greenhouse environmental conditions (for example: temperature or light intensity) or differences in virus content of curly top source plants may have caused these differences in intensity of disease exposure.

Results are summarized in Table 2. There were striking differences in curly top reaction between the entries, ranging from about 56 to 175 percent of that of check variety US 41.

In some entries in which segregation for curly top resistance was indicated, the most resistant plants were selected and submitted to the plant breeders concerned for possible use as parents in the program of improving curly top resistance. From 6 Fort Collins entries and 23 Logan entries, a total of 80 plants were thus selected.

^{1/} Schneider, C. L., 1964. Greenhouse tests of curly top resistance. Sugarbeet Research-1964 Report. USDA, ARS, CRD: 98-105.

Among the entries in the greenhouse tests were 140 that were included in a field test of curly top resistance conducted by A. M. Murphy in 1966 near Thatcher, Utah. The curly top ratings of the 140 lines obtained in greenhouse and field tests are presented in a correlation table. (Table 3).

Table 1

INCIDENCE AND SEVERITY OF CURLY TOP IN CHECK VARIETY US 41 IN GREENHOUSE
TESTS AT LOGAN, UTAH IN 1966

Test <u>a/</u> No.	Pct. Plants <u>b/</u> with Curly Top	C. T. <u>c/</u> Grade		Test <u>a/</u> No.	Pct. Plants <u>b/</u> with Curly Top	C. T. <u>c/</u> Grade
1	95	4.8		17	80	4.7
2	95	4.9		18	56	5.3
3	95	5.2		19	55	6.1
6	100	5.2		20	44	5.4
7	90	5.0		21	83	7.5
8	95	4.5		22	71	7.5
9	90	4.6		23	81	6.4
10	95	4.9		24	90	5.9
11	75	5.3		25	77	6.6
12	85	5.8		26	95	6.1
13	90	4.7		27	31	5.8
14	90	6.2		28	64	6.5
15	90	6.4		29	85	5.2
16	84	6.0		30	100	6.7

Mean=81.5, 5.7

a/ Test numbers 4 and 5 were abandoned because most of the plants were accidentally lost.

b/ In most cases, 20 plants were inoculated.

c/ Curly top severity ratings ranged from 1 (very light disease symptoms) to 9 (plant dead).

Table 2

DISTRIBUTION ACCORDING TO CURLY TOP RATING OF 247 SEED LOTS TESTED IN THE
GREENHOUSE AT LOGAN, UTAH IN 1966

<u>Curly top rating in % of US 41</u>	<u>No. of Seed Lots in Each Rating Class</u>
56 - 60	1
66 - 75	6
76 - 85	29
86 - 95	54
96 - 105	41
106 - 115	40
116 - 125	28
126 - 135	25
136 - 145	16
146 - 155	5
156 - 165	1
166 - 175	1

Table 3.

COMPARISON OF CURLY TOP RATINGS OF 140 SUGARBEET LINES IN GREENHOUSE AND
FIELD TESTS: NUMBER OF LINES IN EACH CURLY TOP RATING CLASS

Ratings in Greenhouse Tests ^{1/} (In percent of US 41)	Rating in Field Test ^{1/} ^{2/}									
	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0
60-69					2					
70-79				1	2	1				
80-89			2	3	9	7	3	1		
90-99	1	1	-	4	6	10	5			
100-109				1	4	12	3	2		
110-119					2	7	5	3		
120-129						7	9	5	1	
130-139						4	2	4		
140-149						1	3	5		
150-159	-	-	-	-	-	-	-	-	-	-
160-169										1
170-179							1			

Correlation Coefficient = .588** ^{3/}

^{1/} C. T. Ratings from 1 (light infection) to 9 (dead).

^{2/} Field data furnished by A. M. Murphy, Ratings expressed as averages of 2 plots.

^{3/} Correlation coefficient exceeds 1% level of significance according to table in Snedecor "Statistical Methods" (1946).

COMPARISON OF PATHOGENICITY AND VIRULENCE OF CURLY TOP ISOLATES

C.L. Schneider

Pathogenicity and virulence of several curly top virus isolates from the Intermountain and the Great Plains areas were compared on several different plant species in the greenhouse. Two of the isolates were derived from beet leafhoppers (Eutettix tenellus) collected in a desert breeding area near Promontory, Utah. (Isolates A-1-A, A-3-B). Two were derived from a plant of Phacelia sp. with symptoms of curly top (isolates D-1-B, D-1-E). The rest were from sugarbeet plants with curly top symptoms.

Inasmuch as mixtures of pathogenic strains of curly top can coexist on the same host plant, efforts were made at the beginning to "purify" the curly top isolates in order to increase the likelihood that each comprised no more than one pathogenic strain of the virus. On each virus source-plant, leafhoppers from a non-virulent stock were caged for 7 days, then transferred singly in small leaf-cages to seedlings of a relatively curly top-resistant sugarbeet variety for about 8-12 hours. From among the comparatively few plants that subsequently developed curly top after such a short feeding period, the virus cultures used in this study were established.

Inoculation tests to determine pathogenicity and virulence were conducted in the greenhouse. Non-viruliferous leafhoppers were first placed on source-plants of the different isolates. After a virus acquisition period of about 7 days, the insects were transferred to seedlings for feeding periods of about 7 days. On sugarbeet, Capsella, and Chenopodium seedlings, a small cage-containing one leafhopper--was placed on each cotyledon. Young Turkish tobacco plants (var. Samsoun) were inoculated by placing a glass cylinder (approx. 15 x 15 cm.), with a Saran screen top, on each 6" pot of 3 seedlings and introducing 7 viruliferous leafhoppers in each cage. Included in most tests, as a basis of comparison, was highly virulent curly top strain 11 that had been supplied by Dr. C. W. Bennett. Assessment of degree of curly top infection was made about 6 weeks after the first day of exposure to the vector.

Results (Table 1) indicate differences in virulence among the isolates on each susceptible host and differences in pathogenicity on tobacco. Although some of the isolates are about equal to curly top strain 11 in virulence on sugarbeet they are not among the most virulent isolates that have been collected from the Intermountain region. In previous report(2), isolates of curly top were reported that appeared to be more virulent than strain 11.

Three of the isolates, although highly virulent on sugarbeet, did not cause curly top symptoms on Turkish tobacco. In several previous tests, 2 of the isolates (B-6-A and B-6-D) consistently failed to cause curly top on tobacco (3), hence it is assumed that they are of a different pathogenic strain of the virus than the rest of the isolates tested.

Strains of curly top virus pathogenic on Chenopodium murale and on cucumber have recently been reported (1). None of the isolates reported herein, nor those included in previous tests (2,3) were pathogenic on the 2 Chenopodium species. In an exploratory test however, a curly top culture derived from isolate A-1-A of the present study, was shown to attack cucumber. Young cucumber plants of variety "Boston Pickling" exposed to 3 curly top cultures (6 viruliferous insects per plant). Efforts to transmit the virus to sugarbeet seedlings from cucumber plants exposed to 2 of the isolates and to control plants with leafhoppers were unsuccessful. From cucumber plants exposed to isolate A-1-A-3, however, curly top symptoms were readily transmitted to 17 out of 19 test plants.

Literature Cited

1. Bennett, C. W., 1964, Additional strains of the curly top virus. Sugarbeet Research, 1964 Report. (CR-4-65). U.S.D.A., ARS, CRD: 325-327.
2. Schneider, C. L., 1963. Curly top disease investigations. Sugarbeet Research, 1963 Report. (CR-4-64). U.S.D.A., ARS, CRD: 102-109.
3. _____ 1964. Studies on pathogenic strains of curly top virus. Sugarbeet Research, 1964 Report. (CR-4-64). U.S.D.A., ARS, CRD: 94-97.

Table 1.

INCIDENCE ^{a/} AND SEVERITY ^{b/} OF CURLY TOP ON SEEDLINGS OF SEVERAL PLANT SPECIES INOCULATED IN THE GREENHOUSE WITH CURLY TOP ISOLATES FROM INTERMOUNTAIN AND GREAT PLAINS AREAS

Curly Top Isolate and Source	Test 1 Sugarbeet US 68		Test 2 Sugarbeet US33		Test 3 Capsella bursa pastoris		Test 4 Turkish tobacco		Test 5 Chenopodium murale		Test 6 Chenopodium amaranticolor	
	Inc.	Sev.	Inc.	Sev.	Inc.	Sev.	Inc.	Sev.	Inc.	Sev.	Inc.	Sev.
A-1-A; Thatcher, Utah, 1962	13/20	3.7	12/12	5.8	1/12	5.0	4/14	6.7	0/3			0/3
A-3-B; Thatcher, Utah, 1962	c/	c/	10/12	6.3	c/	c/	c/	c/	---			---
B-4-B; Jerome, Idaho, 1963	c/	c/	8/12	5.5	c/	c/	c/	c/	---			---
B-6-A-1; N. Logan, Utah, 1963	c/	c/	12/12	6.1	1/12	4.0	c/	c/	0/3			---
B-6-A-3; N. Logan, Utah, 1963	4/20	3.5	11/12	6.6	c/	c/	0/6	0	0/3			0/3
B-6-D-1; N. Logan, Utah, 1963	c/	c/	3/12	6.0	c/	c/	0/6	0	---			---
B-9-B; Riverton, Utah, 1963	c/	c/	11/12	6.6	c/	c/	6/6	6.3	---			---
C-1-A; St. George, Utah, 1964	14/20	4.4	12/12	6.1	5/12	4.6	1/6	6.0	0/3			0/3
C-2-A; Logan, Utah, 1964	11/20	4.8	12/12	7.2	6/12	7.2	3/6	8.0	0/3			0/3
C-3-B; Gibbon, Nebr, 1964	16/20	3.7	9/12	4.3	10/12	8.4	6/6	6.5	0/3			0/3
C-4-C; Holcomb, Kan., 1964	12/20	5.1	11/12	4.5	9/12	7.6	2/6	7.0	0/3			0/3
C-5-A; Ft. Collins, Colo., 1964	14/20	5.1	12/12	4.9	4/12	7.5	2/6	7.5	0/3			0/3
C-6-C; Ft. Collins, Colo., 1964	18/20	5.2	11/12	7.4	10/12	7.0	5/6	7.6	0/3			0/3
D-1-B; Logan, Utah, (Phacelia sp.), 1965	14/20	4.6	---	---	---	---	---	---	---			---
D-1-E; Logan, Utah, (Phacelia sp.), 1965	---	---	11/12	6.7	---	---	0/6	0	0/3			0/3
Strain 11, Salinas, Calif.	---	---	5/12	7.8	---	---	6/6	7.5	0/3			0/3
Control	0/20	0	0/12	0	0/12	0	0/6	0	0/3			0/3

^{a/} No plants with curly top symptoms/total plants inoculated

^{b/} Severity expressed numerically from 0 (no symptoms) to 9 (plant dead).

c/ Previously tested and reported (2,3).

P A R T IV

Progress reports of research conducted at
Colorado State University, Fort Collins, Colorado
by the
Staff of Sugarbeet Investigations, ARS-USDA
in cooperation with:

Colorado Agricultural Experiment Station
and
Beet Sugar Development Foundation,
Fort Collins, Colorado

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DEVELOPMENT AND EVALUATION OF SUGARBEET BREEDING
MATERIAL AND VARIETIES CARRYING RESISTANCE TO
LEAF SPOT AND CURLY TOP, 1966^{1/}

John O. Gaskill, Charles L. Schneider,
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Research at Fort Collins in 1966, directed toward the development and evaluation of sugarbeet breeding material and varieties with combined resistance to leaf spot and curly top (LSR-CTR), in general, was similar to that of the preceding year (2)^{3/}. Important contributions to this research program were made by other U. S. Department of Agriculture experiment stations and by several state and sugar company stations. A substantial portion of the work performed at Fort Collins during the year was of a service character--e.g. evaluation of the leaf spot resistance of breeding lines, varieties, etc., for other U.S.D.A. stations and several sugar companies. This report is not intended to present results of such tests. Details pertaining to the breeding work, preliminary observational evaluation of breeding lines, etc., also have been largely omitted.

^{1/} This progress report pertains to breeding and evaluation work conducted at Fort Collins, Colorado, and to cooperative tests conducted elsewhere by various investigators, with results compiled at the Fort Collins station. The work at Fort Collins was performed by the Crops Research Division, A.R.S., U. S. Department of Agriculture, in cooperation with the Colorado Agricultural Experiment Station (Project 149) and the Beet Sugar Development Foundation (Project 25), and was supported in part by funds contributed by the National Sugar Manufacturing Company. Assistance rendered by Luther W. Lawson, Agricultural Research Technician, Crops Research Division, in conducting breeding, evaluation, and other work at Fort Collins is acknowledged. Participation by other investigators in the research program covered by this report is acknowledged in the tables and accompanying discussion.

^{2/} Research Plant Pathologist, Plant Pathologist, Research Agronomist, and Geneticist, respectively, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture.

^{3/} Numbers in parentheses pertain to Literature Cited.

High Lights of Accomplishments

1. Results of extensive, cooperative, agronomic, evaluation tests at various locations in 1966 confirmed results of the preceding year (2) in showing high productivity and acceptable sucrose percentage for the monogerm hybrid, SL (129 x 133) x SP 6322-0. This hybrid is intermediate in resistance to leaf spot, curly top, and Aphanomyces type black root.
2. In three replicated tests (Exp. 3A, 4A, and 17A, with at least 8 replications in each), under severe leaf spot exposure at Fort Collins in 1966, the monogerm hybrid, FC (502/2 x 504) x FC 901, consistently exceeded the standard variety, SL (129 x 133) x SP 6322-0, in yield of roots and gross sucrose and in sucrose percentage. The difference between the two varieties in gross sucrose yield was significant in every case. The 3-test averages for FC (502/2 x 504) x FC 901, expressed as percent of the corresponding averages for the standard variety, were as follows: gross sucrose yield, 113.9; root yield, 109.8; and sucrose percentage, 104.1. The difference between the two varieties for each attribute far exceeded the 1-percent level of significance.
3. Progress in 1966 in the development of new LSR-CTR, monogerm, type-0, inbred lines was encouraging, and one of the newer lines of this type, SP 642090sl, appeared to have high combining ability for yield. The hybrid, FC 901 aa x SP 642090sl, in a replicated test under severe leaf spot conditions (Exp. 17A), was somewhat above FC (502/2 x 504) x FC 901 in yield of both roots and gross sucrose. It was significantly below the latter hybrid in sucrose percentage, but was somewhat above the standard variety in that regard. It surpassed the standard variety by highly significant amounts in yield of both roots and gross sucrose.
4. Encouraging progress was shown in the use of the seedling induction technique (1) as a tool in the selection for and evaluation of bolting resistance. The LSR-CTR, multigerm variety, FC 901, was used as source material in this study.

Observational Evaluation of LSR-CTR
Monogerm, Type-0, Inbred Lines

Leaf spot and curly top resistance evaluation of monogerm, type-0, and near-type-0 inbred lines, represented by very small seed lots (i.e. seed obtained by selfing with one or two paper bags), was continued in 1966 with the assistance of Dr. C. L. Schneider, U.S. Department of Agriculture, Logan, Utah. Results for 31 such lines are presented in Table 1 together with pertinent details regarding breeding histories and evaluation techniques. The curly top resistance of one of the inbred lines is illustrated in Figure 1. The results at Fort Collins were obtained in Experiment 6A.

The lines evaluated included four sublines of FC 601. Each of those sublines was substantially superior to SP 5481-0 and US 41 in leaf spot and curly top resistance, respectively. Eight other lines, representing two different sources, were about equal to SP 5481-0 in leaf spot resistance and approximately equal to or higher than US 41 in curly top resistance.

Table 1 --Evaluation of leaf spot and curly top resistance of monogerm, type-0 and near type-0, inbred lines of sugarbeet, Fort Collins, Colorado, and Logan, Utah, 1966.

Description and/or source	: Immediate parent	: Line no. (seed no.)	: No. gen. self.	: Pol. rating	: a/ 0- b/ rat- ing	: Ft. Col. Exp. no. 6A Entry: of no. :plots: 8/25 :8/10	: No. :leaf e/ Vig.	: c/ Logan greenhouse Code : No. :Curly no. :inf. :top	: d/ e/ f/ g/ h/ i/ j/ k/			
SP 611100-0 <u>h</u> /; SP 622027s1	SP 641155HOA	SP 652013s1	2	5	100/0	406	2	2.0	4.0	66-2	18	124
" " " " " "	" " " " " "	652024s1	2	6	76/0	408	2	2.5	4.5	" -3	20	139
" 611101-0 <u>i</u> /	" 632028s1	" 652019s1	2	5	100/0	410	2	2.0	4.5	" -4	20	145
" " " " " "	" 632037s1	" 652074s1	2	6	100/0	412	1	4.0	4.0	" -5	17	106
" " " " " "	" 632072s1	" 652070s1	2	5	100/0	413	1	3.0	5.0	" -6	17	90
" " " " " "	" 632093s1	" 652049s1	2	6	100/0	417	1	3.0	5.0	" -7	18	98
" " " " " "	" 632106s1	" 652102s1	2	7	95/5	423	2	3.5	4.5	" -8	20	85
" " " " " "	" 632109s1	" 652078s1	2	5	100/0	425	1	4.0	4.0	" -9	20	108
" " " " " "	" " " " " "	652094s1	2	6	96/4	427	2	4.0	4.5	" -10	20	104
" " " " " ; SP 622071s1 (FC 601)"	641156HOA	" 652000s1	2	5	100/0	429	2	2.0	4.0	" -11	18	85
" " " " " ; " " " (" " ")"	" " " " " "	652014s1	2	5	100/0	431	2	2.5	4.0	" -12	20	73
" " " " " ; " " " (" " ")"	" " " " " "	652016s1	2	6	100/0	433	2	2.5	4.5	" -13	17	81
" " " " " ; " " " (" " ")"	" " " " " "	652017s1	2	5	100/0	435	2	2.0	4.5	" -14	17	88
" 621103-0 <u>i</u> /	" 632025s1	" 652005s1	2	6	96/4	439	2	3.0	4.5	" -16	18	115
" " " " " "	" " " " " "	652006s1	2	4	100/0	441	2	4.0	4.5	" -17	17	111
" " " " " "	" " " " " "	652007s1	2	6	100/0	443	2	3.5	5.0	" -18	17	117
" " " " " "	" 632033s1	" 652050s1	2	5	100/0	447	2	4.5	4.0	" -19	19	79
" " " " " "	" " " " " "	652077s1	2	6	100/0	449	1	3.0	5.0	" -20	17	102
" " " " " "	" 632034s1	" 652088s1	2	5	83/0	451	2	3.0	5.0	" -21	17	130
" " " " " "	" 632035s1	" 652067s1	2	5	80/5	458	1	4.0	4.0	" -24	15	85
" " " " " "	" 632067s1	" 652048s1	2	6	92/4	462	2	3.5	5.5	" -25	9	100
" " " " " "	" " " " " "	652098s1	2	6	83/0	464	2	3.5	4.5	" -26	18	136
" " " " " "	" 632095s1	" 652043s1	2	6	92/0	466	2	3.5	4.5	" -27	16	92
" " " " " "	" " " " " "	652062s1	2	5	92/0	468	2	3.0	5.0	" -28	20	92
" " " " " "	" " " " " "	652069s1	2	4	87/0	470	1	4.0	4.0	" -29	19	121
" " " " " "	" " " " " "	652073s1	2	6	100/0	471	1	3.0	4.0	" -30	19	108
" " " " " "	" " " " " "	652075s1	2	5	100/0	472	2	3.0	5.0	" -31	19	117
SP 571803-00 <u>k</u> /; SP 592262.;												
SP 612070s1	" 631170HO	" 652018s1	3	4	90/5	474	2	3.0	3.5	" -32	19	146
do.	" " " " " "	652020s1	3	5	91/0	476	1	3.0	4.0	" -33	17	127
do.	" " " " " "	652021s1	3	5	100/0	478	1	4.0	4.0	" -34	20	129
do.	" " " " " "	652023s1	3	5	95/5	480	1	3.0	4.0	" -35	17	137
SP 5481-0		Acc. 2483				495	9	3.2	6.0	" -36	59	143
SP 6051-0		SP 631210HO								" -37	56	99

a/ Quantity of pollen (per flower) shed by the individual plant that was selfed to produce the indicated seed no. Basis of grades: 1-7 in ascending order of abundance (ordinary, open-pollinated, commercial variety usually rated 6 or 7).

b/ Pertains to the indexing population (at least 16, but usually 20 or more plants); left number is percentage classed as male sterile; right number is percentage classed as male fertile; percentage unaccounted for, if any, represents intermediate types.

c/ Field plots on Hospital Farm, Ft. Collins, Colo.; inoculation and frequent sprinkling used to promote leaf spot development; plots 1 row x 20', flanked uniformly by rows of a leaf spot susceptible line.

d/ Curly top resistance evaluation by C.L. Schneider, Logan, Utah, using greenhouse seedling technique with Schneider's culture A1A of the curly top virus, and 2 caged leafhoppers per plant. Ordinarily 20 plants were inoculated per line. Except for code no. 66-25, of which 14 plants were inoculated, at least 18 plants were inoculated per line.

e/ Leaf spot grades (K.G. Gould): 0 = no leaf spot; 10 = complete defoliation.

f/ Foliage vigor (K.G. Gould): Larger no. = greater vigor.

g/ Curly top severity (C.L. Schneider). The plants were classified individually on a scale of 0 - 9 (0 = no symptoms, 9 = dead). Plants without curly top symptoms were disregarded. Results for plants with curly top symptoms were averaged by lines, and the averages were converted to percent of US 41. Thus, values less than 100 (shown above) indicate less curly top injury than in US 41, and values greater than 100 indicate more curly top injury than in US 41.

h/ SP 611100-0: LSR-CTR, mm, with SLC 122-0 cytoplasm; derived from backcrossing program; 50% SLC 122-0 blood; 12 1/2% US 201 blood; segregating for type-0 and aa.

i/ SP 611101-0: Same as SP 611100-0 except that the cytoplasm was derived from the multigerm variety, SL 202.

j/ SP 621103-0: LSR-CTR, mm, with SLC 117-0 cytoplasm; derived from backcrossing program; 50% SLC 117-0 blood; 12 1/2% US 201 blood; segregating for type-0 and aa.

k/ SP 571803-00: F₂, US 201 (LSR MM) x SLC 91 (CTR mm).



Fig. 1.--Comparison of two sugarbeet lines (A and B), in resistance to curly top, in greenhouse test, Logan, Utah, 1966. Except for the last pot in each row (non-inoculated), all plants were inoculated with curly top in the early seedling stage. A--code No. 66-14 (SP 652017x1, an S_2 inbred and a sub-line of FC 601); 20 plants inoculated; 17 infected. B--code No. 66-36 (SP 5481-0, an open-pollinated variety); 20 plants inoculated; 20 infected. (Logan photo. No. 66D-28).

Preliminary Appraisal of Combining Ability
of LSR-CTR, Monogerm, Type-0, Inbred Lines

Use of the reciprocal top-cross technique was continued in 1966 for preliminary appraisal of combining ability of LSR-CTR, monogerm, type-0 or near-type-0, inbred lines. Experimental techniques employed at Fort Collins (Exp. 17A) and at Thatcher, Utah, are described in Table 2. The summarized results are presented in that table, and varietal contrasts under leaf spot conditions are shown in Figure 2.

Experiment 17A included two checks, both of which had performed quite well in the cooperative tests of LSR-CTR varieties in 1965 (2). One of these (entry 506) is the commercial variety, SL (129 x 133) x SP 6322-0, which was used as the "standard variety" in numerous tests in 1966. The other check, FC (502/2 x 504) x FC 901 (entry 505), exceeded the standard variety significantly in both gross sucrose yield and sucrose percentage in Experiment 17A. These results and others presented elsewhere in this report are in keeping with the performance of FC (502/2 x 504) x FC 901 in various tests in 1965 (2).

One of the reciprocal top-cross hybrids in Experiment 17A, entry 504, was somewhat above entry 505 in yield of both roots and gross sucrose. Entry 504 was significantly lower than 505 in sucrose percentage, but it was somewhat above the standard variety in that regard. It surpassed the standard variety by highly significant amounts in yield of roots and gross sucrose.

Another reciprocal top-cross hybrid (entry 501) was rather attractive. It was significantly higher than the standard variety in sucrose percentage, somewhat higher in root yield, and exceeded the standard variety in acre yield of gross sucrose by 351 pounds (450 required for significance).

Both entries 501 and 504 apparently are superior to the standard variety in leaf spot resistance, as shown in Table 2, and this difference presumably was partly responsible for the relatively high agronomic performance of those two entries in Experiment 17A where leaf spot exposure was severe. Curly top was not a factor in that test, but it is important to recognize that, according to the Thatcher test (Table 2), entries 501 and 504 apparently are superior to the standard variety and about the same as the curly top resistant check, US 41, in curly top resistance. The entry with the lowest (best) curly top grade (entry 503) was about the same as entries 501 and 504 in leaf spot resistance, outstanding in sucrose percentage, but low in root yield.



Fig. 2.--Comparison of two LSR-CTR hybrids, in 1-row plots, with R & G Pioneer (European variety) under severe leaf spot exposure; Exp. 17A, Fort Collins, Colorado, September 9, 1966; left to right:

- (a) Two rows of Pioneer
- (b) Entry 503, FC 901 aa ♀ x
SP 642063s1
- (c) Entry 505, FC (502/2 x 504)
MS ♀ x FC 901

(Fort Collins photo. No. 184-31).

Top-cross Tests at Fort Collins, Colorado, and Thatcher, Utah

Four sets of top-cross hybrids were evaluated in separate agronomic tests at Fort Collins, under severe leaf spot exposure, and two of those sets also were tested for curly top resistance in observational plots at Thatcher, Utah. Each of the tests at Fort Collins involved 32 entries, equalized random block design, and 4 replications. Plots were 1 row x 20 ft. in size. An accurately measured section in each plot (usually about 17 ft. of row) was harvested for root yield and sucrose determinations. Severe leaf spot exposure was developed with the aid of inoculation and frequent sprinkling. The test at Thatcher, conducted by A. M. Murphy, involved plots 1 row x 50 ft. in size, 2 replications, and artificial intensification of curly top exposure.

Descriptions of the females and pollinators, serving as parents of the top-cross hybrids, are given in Table 3. Hybrids classed as resistant to leaf spot and black root (i.e. LSR-BRR) were included in Experiments 2A-1 and 2A-2. Results for those tests are presented in Tables 4, 5, 6, and 7. Hybrids classed as resistant to leaf spot and curly top (i.e. LSR-CTR) were included in Experiments 3A-1 and 3A-2, and the results are given in Tables 8, 9, 10, and 11. The curly top results obtained at Thatcher are shown in Table 12.

The harvest results of Experiments 2A-1, 2A-2, 3A-1, and 3A-2 failed to show outstanding potential for any female lines not previously recognized as good "combiners". The over-all average gross sucrose yield for all hybrids of FC 504 (designated H031) was 4902 lbs. per acre compared with an average of 4507 for all plots of the check variety, SL (129 x 133) x SP 6322-0 (Acc. 2636 and 2646). The difference (395 lbs.) was substantially above the 5% level of significance (<354). The over-all average gross sucrose yields for all hybrids of each of the respective sublines of FC 502 were as follows:

<u>Subline</u>	<u>Average gross sucrose for all hybrids (lbs.)</u>
FC 502/2	4722
FC 502/3	4710
SP 612046s1	4611

The over-all average gross sucrose yield for all hybrids having FC 502/2 x SP 581181s1 (i.e. j x f) as the female parent was 5027. The gross sucrose average for SL (129 x 133) x SP 6322-0, comparable with the stated averages for the "j x f" hybrids and the hybrids involving FC 502 sublines, is 4507.

The hybrid, FC (502/2 x 504) x FC 901, referred to elsewhere in this report (see Tables 2 and 15 and accompanying discussions) occurred as one of the standard or check varieties in Experiment 3A-1 and 3A-2. The average gross sucrose yield for that hybrid was 5515 pounds per acre, 864 pounds greater than the average for the two accessions of SL (129 x 133) x SP 6322-0. This difference was highly significant.

Since the hybrids representing the different pollinators were in separate Fort Collins tests, direct comparisons between pollinators cannot be made with the results of those tests. Relative performance of two sets of hybrids may be seen in the following table in which the averages for all 27 top-cross hybrids in each of two tests are expressed as percentages of the corresponding averages for the five varieties listed as standards:

	Exp. 3A-1 <u>(FC 901♂)</u>	Exp. 3A-2 <u>(663 ♂)</u>
Gross sucrose yield	91.46	88.78
Root yield	90.15	88.74
Sucrose %	101.57	100.41
Leaf spot	98.59	103.76

None of the top-cross hybrids listed in Table 12 escaped severe injury under the extremely severe curly top exposure at Thatcher. However, several equaled the CTR check, US 41, in curly top grade.

Table 3 --Description of parental material involved in top-cross tests, Ft. Collins, Colo., 1966(Exp. 2A-1, 2A-2, 3A-1, and 3A-2).

Line no.	Temp. code	No. ^{a/} gen. self.	Description &/or source
<u>I. Monogerm, type-0, LSR, inbred lines</u>			
FC 502		1	V.F.S. 715 mm ♀ x US 201 MM
" 502/2	j	2	SP 602008s1; subline of FC 502
" 502/3		2	" 612113s1; " " " "
" 503		2	Derived from V.F.S. 716
" 504		2	" " " 6-2
" 505	h	2	SP 602063s1; US 201 MM x T.O. mm
" 601 ^{b/}		1	" 622071s1; SP 611101-0
SP 581181s1	f	1	US 201 MM x T.O. mm
" 581222s1	i	1	" " " x " "
" 592087s1		2	SP 571303s1; US 201 MM x SP 51101- lines mm
" 602105s1	g	2	" 581194s1; US 201 MM x T.O. mm
" 602116s1	e	2	" 581179s1; " " " x " "
" 612003s1 ^{b/}		2	" 591713.; SP 551556. mm x SLC 91 mm
" 612033s1		3	" 592084s1; US 201 MM x SP 51101- lines mm
" 612046s1		2	Subline of FC 502
" 612054s1		2	SP 591518.; US 201 MM x T.O. mm
" 612068s1		3	" 592094s1; US 201 MM x T.O. mm
" 612070s1 ^{b/}		2	" 592262.; US 201 MM x SLC 91 mm
" 612083s1		2	" 581220s1; US 201 MM x T.O. mm
" 622027s1 ^{b/}		1	" 611100-0
<u>II. Pollinators (multigerm)</u>			
FC 901			LSR-CTR; prod. of B.C.; US 201 non-recur. parent
McF. 663			CTR-bolt. res., from Salinas, Calif. (J.S. McFarlane)
SP 5822-0			LSR-BRR, from Beltsville, Md. (G. E. Coe)
SP 59B18-0			" " , from E. Lansing, Mich. (G.J. Hogaboam)

^{a/} Numbers indicate known generations of selfing; additional selfing may have occurred.

^{b/} On the basis of ancestry, the line is expected to have some curly top resistance.

Table 4 .--Results of top-cross tests; LSR-BRR, monogerm hybrids, Ft. Collins, Colo., 1966; Exp. 2A-1 & 2A-2; basic data presented as 4-plot averages.

<u>Gross Sucrose per Acre (Lbs.)</u>						
♀			Hyb. no.	<u>Experiment no. and pollinator</u>		
CMS of mm, T.O. lines below				Exp. 2A-1	Exp. 2A-2	Average
Line no.	Eq. stage	T. code		SP 5822-0	SP 59B18-0	
<u>I. 1965 top-cross hybrids</u>						
SP 612003s1	B ₁		H01	3811	4111	3961
" 612070s1	B ₁		H02	3612	4013	3813
" 592087s1	B ₁		H03	3840	4791	4316
" 612033s1	B ₂		H04	3807	4212	4010
	B ₃					
" 612046s1	B ₃ (+)		H05	4157	4477	4317
FC 502/3	B ₃		H06	4552	4955	4754
SP 612068s1	B ₃		H08	3617	4888	4253
" 612054s1	B ₂		H09	3631	4387	4009
	B ₁					
" 612083s1	B ₃ (+)		H010	4031	4154	4093
FC 502 x 503	B ₃		H011	4202	4652	4427
FC 502/2	B ₄	j	H012	4445	4694	4570
		e x j	H013	4540	5056	4798
		g x j	H014	4220	4623	4422
SP 602116s1	B ₃	e	H015	3482		
		g x e	H016	4087	3966	4027
		h x e	H017	4137	4117	4127
		i x e	H018	3829	4135	3982
SP 581181s1	B ₂	f	H019	4382	4424	4403
		e x f	H020	3798	4196	3997
		g x f	H021	3642	4362	4002
		h x f	H022	4498	4791	4645
		i x f	H023	4313	4113	4213
		j x f	H024	4598	4749	4674
FC 505	B ₃	h	H025	3996		
		g x h	H026	3840	4663	4252
		i x h	H027	3823	4358	4091
		j x h	H028	3974	4886	4430
SP 622027s1	B ₁		H029	3891	4682	4287
FC 601	B ₁		H030	3803	4870	4337
FC 504	B ₂		H031	4133	5230	4682
<u>II. Standards</u>						
Acc. 2636[SL(129 x 133) x SP 6322-0]				3899	4816	4358
Acc. 2646[SL(129 x 133) x SP 6322-0]				4331	4409	4370
SP 641201H03 [FC(502/2 x 504) x SP 5822-0]					5334	
SP 641202H03 [FC(502/2 x 504) x SP 59B18-0]					5151	
LSD (.05) for 4-plot averages				675	555	
LSD (.05) for average of averages						437

Table 5 .--Results of top-cross tests; LSR-BRR, monogerm hybrids, Ft. Collins, Colo., 1966; Exp. 2A-1 & 2A-2; basic data presented as 4-plot averages.

Roots per Acre (Tons)						
♀		Hyb. no.	Experiment no. and pollinator			Average
CMS of mm, T.O. lines below	Eq. stage:T. code		Exp. 2A-1	Exp. 2A-2		
Line no.			SP 5822-0	SP 59B18-0		
I. 1965 top-cross hybrids						
SP 612003s1	B ₁	H01	13.16	14.41		13.79
" 612070s1	B ₁	H02	12.58	13.76		13.17
" 592087s1	B ₁	H03	13.87	16.39		15.13
" 612033s1	B ₂	H04	13.79	15.32		14.56
	B ₃					
" 612046s1	B ₃ (+)	H05	13.49	14.75		14.12
FC 502/3	B ₃	H06	14.63	15.94		15.29
SP 612068s1	B ₃	H08	12.54	16.54		14.54
" 612054s1	B ₂	H09	12.63	15.08		13.86
	B ₁					
" 612083s1	B ₃ (+)	H010	13.81	14.77		14.29
FC 502 x 503		H011	13.96	15.54		14.75
FC 502/2	B ₄	j	H012	14.29	15.36	14.83
		e x j	H013	15.19	16.65	15.92
		g x j	H014	14.05	15.46	14.76
SP 602116s1	B ₃	e	H015	12.32		
		g x e	H016	14.29	13.68	13.99
		h x e	H017	14.46	14.76	14.61
		i x e	H018	13.56	14.37	13.97
SP 581181s1	B ₂	f	H019	14.76	14.75	14.76
		e x f	H020	13.59	14.19	13.89
		g x f	H021	12.15	14.35	13.25
		h x f	H022	15.30	16.87	16.09
		i x f	H023	14.23	14.14	14.19
		j x f	H024	14.79	15.70	15.25
FC 505	B ₃	h	H025	14.05		
		g x h	H026	13.29	15.41	14.35
		i x h	H027	13.07	14.75	13.91
		j x h	H028	13.44	16.28	14.86
SP 622027s1	B ₁	H029	13.28	16.02		14.65
FC 601	B ₁	H030	13.03	16.34		14.69
FC 504	B ₁	H031	14.64	18.34		16.49
	B ₂					
II. Standards						
Acc. 2636 [SL(129 x 133) x SP 6322-0]			13.57	16.38		14.98
Acc. 2646 [SL(129 x 133) x SP 6322-0]			15.30	15.79		15.55
SP 641201H03 [FC(502/2 x 504) x SP 5822-0]				17.83		
SP 641202H03 [FC(502/2 x 504) x SP 59B18-0]				17.48		
LSD (.05) for 4-plot averages			2.00	1.85		
LSD (.05) for aver. of averages						1.36

Table 6 .--Results of top-cross tests; LSR-BRR, monogerm hybrids, Ft. Collins, Colo., 1966; Exp. 2A-1 & 2A-2; basic data presented as 4-plot averages.

		Sucrose Percentage				
CMS of mm, T.O. lines below		Hyb. no.	Experiment no. and pollinator			
Line no.	Eq. stage	T. code	no.	SP 5822-0	SP 59B18-0	Average
I. 1965 top-cross hybrids						
SP 612003sl	B ₁		H01	14.49	14.22	14.36
" 612070sl	B ₁		H02	14.40	14.53	14.47
" 592087sl	B ₁		H03	13.82	14.62	14.22
" 612033sl	B ₂		H04	13.81	13.72	13.77
	B ₃					
" 612046sl	B ₃ (±)		H05	15.36	15.17	15.27
FC 502/3	B ₃		H06	15.54	15.49	15.52
SP 612068sl	B ₃		H08	14.38	14.79	14.59
" 612054sl	B ₂		H09	14.32	14.55	14.44
	B ₁					
" 612083sl	B ₃ (±)		H010	14.60	14.08	14.34
FC 502 x 503			H011	15.01	14.95	14.98
FC 502/2	B ₄	j	H012	15.51	15.27	15.39
		e x j	H013	14.94	15.15	15.05
		g x j	H014	15.02	14.94	14.98
SP 602116sl	B ₃	e	H015	14.05		
		g x e	H016	14.26	14.50	14.38
		h x e	H017	14.25	13.95	14.10
		i x e	H018	14.15	14.39	14.27
SP 581181sl	B ₂	f	H019	14.82	14.92	14.87
		e x f	H020	13.97	14.74	14.36
		g x f	H021	14.99	15.19	15.09
		h x f	H022	14.69	14.19	14.44
		i x f	H023	15.10	14.57	14.84
		j x f	H024	15.52	15.09	15.31
FC 505	B ₃	h	H025	14.22		
		g x h	H026	14.45	15.15	14.80
		i x h	H027	14.61	14.74	14.68
		j x h	H028	14.76	14.98	14.87
SP 622027sl	B ₁		H029	14.66	14.60	14.63
FC 601	B ₁		H030	14.59	14.89	14.74
FC 504	B ₂		H031	14.09	14.24	14.17
II. Standards						
Acc. 2636 [SL(129 x 133) x SP 6322-0]				14.36	14.67	14.52
Acc. 2646 [SL(129 x 133) x SP 6322-0]				14.09	13.96	14.03
SP 641201H03 [FC(502/2 x 504) x SP 5822-0]					14.97	
SP 641202H03 [FC(502/2 x 504) x SP 59B18-0]					14.74	
LSD (.05) for 4-plot averages				0.68	0.60	
LSD (.05) for aver. of averages						0.45

Table 7 .--Results of top-cross tests; LSR-BRR, monogerm hybrids, Ft. Collins, Colo., 1966; Exp. 2A-1 & 2A-2; basic data presented as 4-plot averages.

Leaf Spot Grades ^{a/}						
♀		: Experiment no. and pollinator				
CMS of mm, T.O. lines below		: Hyb. no.		: Exp. 2A-1 : Exp. 2A-2		: Average
Line no.	: Eq. stage:	T. code	:	SP 5822-0	SP 59B18-0	:
I. 1965 top-cross hybrids						
SP 612003s1	B ₁		H01	3.00	3.50	3.25
" 612070s1	B ₁		H02	3.00	3.25	3.13
" 592087s1	B ₁		H03	3.00	3.00	3.00
" 612033s1	B ₂		H04	3.00	3.25	3.13
" 612046s1	B ₃		H05	2.50	3.25	2.88
FC 502/3	B ₃ (±)		H06	2.50	3.00	2.75
SP 612068s1	B ₃		H08	3.00	2.75	2.88
" 612054s1	B ₂		H09	3.25	3.25	3.25
" 612083s1	B ₁		H010	3.50	3.50	3.50
FC 502 x 503	B ₃ (±)		H011	3.25	4.00	3.63
FC 502/2	B ₄	j	H012	2.75	3.00	2.88
		e x j	H013	3.00	3.00	3.00
		g x j	H014	3.50	3.50	3.50
SP 602116s1	B ₃	e	H015	3.25		
		g x e	H016	3.25	3.75	3.50
		h x e	H017	3.50	3.50	3.50
		i x e	H018	3.25	3.50	3.38
SP 581181s1	B ₂	f	H019	3.00	3.75	3.38
		e x f	H020	4.00	4.25	4.13
		g x f	H021	3.25	3.75	3.50
		h x f	H022	3.00	3.75	3.38
		i x f	H023	3.25	3.75	3.50
		j x f	H024	2.50	3.25	2.88
FC 505	B ₃	h	H025	3.50		
		g x h	H026	3.50	3.00	3.25
		i x h	H027	3.50	3.75	3.63
		j x h	H028	3.00	3.00	3.00
SP 622027s1	B ₁		H029	3.00	3.00	3.00
FC 601	B ₁		H030	2.75	3.00	2.88
FC 504	B ₂		H031	3.00	2.75	2.88
II. Standards						
Acc. 2636 [SL(129 x 133) x SP 6322-0]				3.75	3.75	3.75
Acc. 2646 [SL(129 x 133) x SP 6322-0]				3.50	4.25	3.88
SP 641201H03 [FC(502/2 x 504) x SP 5822-0]					2.25	
SP 641202H03 [FC(502/2 x 504) x SP 59B18-0]					3.00	
LSD (.05) for 4-plot averages				0.56	0.64	
LSD (.05) for aver. of averages						0.43

^{a/} Leaf spot grades (by K.G. Gould, 8/25-26/66): 0 = no leaf spot; 10 = complete defoliation.

Table 8 .--Results of top-cross tests; LSR-CTR, monogerm hybrids, Fort Collins, Colo., 1966; Exp. 3A-1 and 3A-2; basic data presented as 4-plot averages.

Gross Sucrose per Acre (Lbs.)						
♀		: Hyb.		: Experiment no. and pollinator		
CMS of mm, T.O. lines below		: no.		: Exp. 3A-1	: Exp. 3A-2	: Average
Line no.	: Eq. stage:	T. code	:	: FC 901	: McF. 663	:
I. 1965 top-cross hybrids						
SP 612003s1	B ₁		HO1	4510	4405	4458
" 612070s1	B ₁		HO2	4410	4316	4363
" 592087s1	B ₁		HO3	4714	5040	4877
" 612033s1	B ₂		HO4	4038	4843	4441
	B ₃					
" 612046s1	B ₃ (±)		HO5	4707	5103	4905
FC 502/3	B ₃		HO6	4563	4767	4665
SP 612068s1	B ₂		HO8	4319	4648	4484
" 612083s1	B ₃ (±)		HO10	4413	4534	4474
FC 502 x 503			HO11	4843	4511	4677
FC 502/2	B ₄	j	HO12	4634	5113	4874
		e x j	HO13	5188	4438	4813
		g x j	HO14	4980	4950	4965
SP 602116s1	B ₃	e	HO15	4956	4021	4489
		g x e	HO16	4616	4385	4501
		h x e	HO17	4778	5173	4976
		i x e	HO18	5270	4186	4728
		e x f	HO20	4184	4201	4193
		g x f	HO21	4199	4978	4589
		h x f	HO22	5236	4690	4963
		j x f	HO24	5651	5108	5380
FC 505	B ₃	h	HO25	4636	4242	4439
		g x h	HO26	4614	4469	4542
		i x h	HO27	4742	4657	4700
		j x h	HO28	4822	4758	4790
SP 622027s1	B ₁		HO29	4131	4498	4315
FC 601	B ₁		HO30	3820	4687	4254
FC 504	B ₂		HO31	5041	5200	5121
II. Standards						
Acc. 2636 [SL(129 x 133) x SP 6322-0]				4997	4393	4695
Acc. 2646 [SL(129 x 133) x SP 6322-0]				4814	4397	4606
Acc. 2168 [GW 674-56C]				4864	6122	5493
SP 641204HO1 [FC(502/2 x 503) x FC 901]				5562	5602	5582
SP 641204HO3 [FC(502/2 x 504) x FC 901]				5279	5751	5515
LSD (.05) for 4-plot averages				678	884	
LSD (.05) for aver. of averages						557

Table 9 .--Results of top-cross tests; LSR-CTR, monogerm hybrids, Fort Collins, Colo., 1966; Exp. 3A-1 and 3A-2; basic data presented as 4-plot averages.

Roots per Acre (Tons)						
♀		:	Hyb.	Experiment no. and pollinator		
CMS of mm, T.O. lines below		:	no.	Exp. 3A-1	Exp. 3A-2	Average
Line no.	Eq. stage:T. code	:	no.	FC 901	McF. 663	
I. 1965 top-cross hybrids						
SP 612003s1	B ₁		H01	14.73	14.11	14.42
" 612070s1	B ₁		H02	14.38	14.23	14.31
" 592087s1	B ₁		H03	15.46	16.32	15.89
" 612033s1	B ₂		H04	13.99	16.52	15.26
" 612046s1	B ₃ (±)		H05	14.34	15.77	15.06
FC 502/3	B ₃		H06	14.00	15.05	14.53
SP 612068s1	B ₃		H08	14.54	15.64	15.09
" 612083s1	B ₃ (±)		H010	14.48	14.61	14.55
FC 502 x 503			H011	15.46	15.36	15.41
FC 502/2	B ₄	j	H012	14.33	15.74	15.04
		e x j	H013	16.43	14.26	15.35
		g x j	H014	15.46	15.42	15.44
SP 602116s1	B ₃	e	H015	16.41	13.30	14.86
		g x e	H016	15.22	14.91	15.07
		h x e	H017	15.98	16.84	16.41
		i x e	H018	16.87	13.73	15.30
		e x f	H020	13.48	14.18	13.83
		g x f	H021	12.89	15.48	14.19
		h x f	H022	16.81	15.20	16.01
		j x f	H024	17.60	15.70	16.65
FC 505	B ₃	h	H025	14.30	13.02	13.66
		g x h	H026	14.34	14.05	14.20
		i x h	H027	14.82	15.54	15.18
		j x h	H028	15.14	14.60	14.87
SP 622027s1	B ₁		H029	13.25	14.60	13.93
FC 601	B ₁		H030	13.23	15.07	14.15
FC 504	B ₂		H031	16.36	17.06	16.71
II. Standards						
Acc. 2636 [SL(129 x 133) x SP 6322-0]				16.23	14.64	15.44
Acc. 2646 [SL(129 x 133) x SP 6322-0]				15.74	14.54	15.14
Acc. 2168 [GW 674-56C]				16.10	19.65	17.88
SP 641204H01 [FC(502/2 x 503) x FC 901]				17.60	18.06	17.83
SP 641204H03 [FC(502/2 x 504) x FC 901]				17.38	17.90	17.64
LSD (.05) for 4-plot averages				1.98	2.60	
LSD (.05) for aver. of averages						1.63

Table 10 --Results of top-cross tests; LSR-CTR, monogerm hybrids, Fort Collins, Colo., 1966; Exp. 3A-1 and 3A-2; basic data presented as 4-plot averages.

Sucrose Percentage						
♀		: Hyb.		: Experiment no. and pollinator		
CMS of mm, T.O. lines below		: no.		: Exp. 3A-1	: Exp. 3A-2	: Average
Line no.	: Eq. stage:	T. code	:	: FC 901	: McF. 663	:
I. 1965 top-cross hybrids						
SP 612003s1	B ₁		HO1	15.29	15.62	15.46
" 612070s1	B ₁		HO2	15.26	15.14	15.20
" 592087s1	B ₂		HO3	15.22	15.42	15.32
" 612033s1	B ₃		HO4	14.42	14.67	14.55
" 612046s1	B ₃ (±)		HO5	16.38	16.19	16.29
FC 502/3	B ₃		HO6	16.30	15.79	16.05
SP 612068s1	B ₂		HO8	14.86	14.84	14.85
" 612083s1	B ₃ (±)		HO10	15.20	15.52	15.36
FC 502 x 503			HO11	15.66	14.60	15.13
FC 502/2	B ₄	j	HO12	16.15	16.24	16.20
		e x j	HO13	15.75	15.51	15.63
		g x j	HO14	16.10	16.04	16.07
SP 602116s1	B ₃	e	HO15	15.10	15.10	15.10
		g x e	HO16	15.19	14.70	14.95
		h x e	HO17	14.96	15.36	15.16
		i x e	HO18	15.64	15.20	15.42
		e x f	HO20	15.52	14.76	15.14
		g x f	HO21	16.22	16.07	16.15
		h x f	HO22	15.57	15.44	15.51
		j x f	HO24	16.04	16.27	16.16
FC 505	B ₃	h	HO25	16.16	16.29	16.23
		g x h	HO26	16.10	15.89	16.00
		i x h	HO27	16.01	14.94	15.48
		j x h	HO28	15.95	16.27	16.11
SP 622027s1	B ₁		HO29	15.59	15.42	15.51
FC 601	B ₁		HO30	14.42	15.52	14.97
FC 504	B ₂		HO31	15.39	15.25	15.32
II. Standards						
Acc. 2636 [SL(129 x 133) x SP 6322-0]				15.35	14.94	15.15
Acc. 2646 [SL(129 x 133) x SP 6322-0]				15.27	15.09	15.18
Acc. 2168 [GW 674-56C]				15.06	15.57	15.32
SP 641204HO1 [FC(502/2 x 503) x FC 901]				15.79	15.45	15.62
SP 641204HO3 [FC(502/2 x 504) x FC 901]				15.19	16.05	15.62
LSD (.05) for 4-plot averages				0.71	0.68	
LSD (.05) for aver. of averages						0.49

Table 11 .--Results of top-cross tests; LSR-CTR, monogerm hybrids, Fort Collins, Colo., 1966; Exp. 3A-1 and 3A-2; basic data presented as 4-plot averages.

Leaf Spot Grades ^{a/}						
♀		:		Experiment no. and pollinator		
CMS of mm, T.O. lines below		:		Hyb.	Exp. 3A-1	Exp. 3A-2
Line no.	Eq. stage:	T. code	:	no.	FC 901	McF. 663
				Average		
I. 1965 top-cross hybrids						
SP 612003s1	B ₁			H01	3.25	3.50
" 612070s1	B ₁			H02	3.75	3.25
" 592087s1	B ₁			H03	3.50	3.00
" 612033s1	B ₂			H04	3.50	3.00
	B ₃					
" 612046s1	B ₃ (±)			H05	3.00	3.25
FC 502/3	B ₃			H06	3.75	3.50
SP 612068s1	B ₃			H08	3.50	4.00
" 612083s1	B ₂					
	B ₃ (±)			H010	3.50	3.75
FC 502 x 503				H011	3.50	3.75
FC 502/2	B ₄	j		H012	3.00	2.75
		e x j		H013	3.75	3.50
		g x j		H014	3.25	3.50
SP 602116s1	B ₃	e		H015	3.75	3.50
		g x e		H016	3.75	3.75
		h x e		H017	3.75	3.75
		i x e		H018	3.50	4.00
		e x f		H020	3.75	4.25
		g x f		H021	4.00	4.00
		h x f		H022	3.50	3.50
		j x f		H024	3.00	3.00
FC 505	B ₃	h		H025	3.75	3.75
		g x h		H026	3.50	4.00
		i x h		H027	3.50	4.00
		j x h		H028	3.25	3.00
SP 622027s1	B ₁			H029	3.75	3.50
FC 601	B ₁			H030	3.00	3.00
FC 504	B ₁			H031	3.50	3.50
	B ₂					

II. Standards						
Acc. 2636 [SL(129 x 133) x SP 6322-0]			3.50	3.50	3.50	
Acc. 2646[SL(129 x 133) x SP 6322-0]			3.75	4.00	3.88	
Acc. 2168 [GW 674-56C]			3.75	3.00	3.38	
SP 641204H01 [FC(502/2 x 503) x FC 901]			3.50	3.50	3.50	
SP 641204H03 [FC(502/2 x 504) x FC 901]			3.25	3.00	3.13	
LSD (.05) for 4-plot averages			0.65	0.58		
LSD (.05) for aver. of averages					0.44	

^{a/} Leaf spot grades (by K.G. Gould, 8/26/66): 0 = no leaf spot;
10 = complete defoliation.

Table 12 .--Curly top resistance evaluation of LSR-CTR, monogerm hybrids, Thatcher, Utah, 1966, by A. M. Murphy. Except where otherwise indicated, the basic results shown are 2-plot averages (each plot 1 row x 50').

♀		Hybrid		Pollinator and curly top grade ^{a/} :		
CMS of mm, T.O. lines below		no.		FC 901 : McF. 663 : Average :		
Line no.	Eq. stage:	T. code :				
I. 1965 top-cross hybrids ^{b/}						
SP 612003s1	B ₁		HO1	7.0	7.5	7.3
" 612070s1	B ₁		HO2	6.5	7.5	7.0
" 592087s1	B ₁		HO3	7.0	8.0	7.5
" 612033s1	B ₂		HO4	8.0	7.5	7.8
" 612046s1	B ₃ (+)		HO5	7.5	7.5	7.5
FC 502/3	B ₃		HO6	7.0	7.0	7.0
SP 612068s1	B ₂		HO8	7.0	7.5	7.3
" 612083s1	B ₃ (+)		HO10	7.0	8.0	7.5
FC 502 x 503			HO11	7.5	8.0	7.8
FC 502/2	B ₄	j	HO12	7.0	7.0	7.0
		e x j	HO13	7.0	7.0	7.0
		g x j	HO14	6.5	7.5	7.0
SP 602116s1	B ₃	e	HO15	6.0	7.0	6.5
		g x e	HO16	7.0	7.5	7.3
		h x e	HO17	6.5	6.5	6.5
		i x e	HO18	6.5	8.0	7.3
		e x f	HO20	6.0	7.5	6.8
		g x f	HO21	7.5	8.0	7.8
		h x f	HO22	7.5	8.5	8.0
		j x f	HO24	7.5	6.0	6.8
FC 505	B ₃	h	HO25	7.5		
		g x h	HO26	6.5	6.0	6.3
		i x h	HO27	7.5	6.0	6.8
		j x h	HO28	6.5	8.0	7.3
SP 622027s1	B ₁		HO29	6.5	8.0	7.3
FC 601	B ₁		HO30	6.0	6.5	6.3
FC 504	B ₂		HO31	7.5	7.0	7.3
Average (excluding HO25)				6.9	7.3	7.2
II. Parental and check material						
SP 651203HO (FC 901)					6.5	
SP 651204HO (McF. 663)					7.5	
Acc. 2483 (SP 5481-0)					8.5	
SP 631210HO (SP 6051-0)					6.5	
US 33 (5 plots)					7.3	
US 41 (6 plots)					6.0	

^{a/} Basis of curly top grades (9/1/66): 0 = healthy; 9 = death due to curly top.

^{b/} Same hybrids as in Experiments 3A-1 and 3A-2, Fort Collins, Colo., 1966.

Cooperators' Tests of Top-cross Hybrids

Some of the top-cross hybrids included in Fort Collins Experiments 2A-1, 2A-2, 3A-1, and 3A-2 were evaluated in agronomic tests by the American Crystal Sugar Company (R. E. Finkner, E. L. Swift, and others) and the Holly Sugar Corp. (D. F. Peterson and P. R. Scott). The tests were similar to other cooperative tests conducted by those companies and described in Tables 29(a) and 32(a). Disease exposures in and harvest results of the cooperators' top-cross tests are summarized in Tables 13 and 14.

Among the LSR-BRR, top-cross hybrids (Table 13), only one exceeded the standard variety, SL (129 x 133) x SP 6322-0, in average gross sucrose yield, and the difference (6 percent) was not significant. Diseases were unimportant in those tests.

The results for the tests of LSR-CTR top-cross hybrids are presented in Table 14. Under severe leaf spot and very severe curly top exposures at Hereford, Texas, the standard variety, SL (129 x 133) x SP 6322-0, was surpassed in gross sucrose yield by one entry, only. The gross sucrose yield of that entry (FC 601 x FC 901) was 4 percent above that of the standard variety and exceeded that of the local check (HH 10) by a highly significant amount. In sucrose percentage, FC 601 x FC 901 was slightly below the standard variety but significantly above the local check. It should be noted that, under mild leaf spot and curly top conditions at Rocky Ford, FC 601 x FC 901 was low in gross sucrose yield. The favorable performance of that hybrid at Hereford is attributed to the fact that, of all the females listed in Table 14, FC 601 is the only one with curly top resistance.

In comparing pollinators (Table 14) insofar as gross sucrose yield of the hybrids is concerned, it seems clear that FC 901 was superior to 663 under the severe disease conditions at Hereford. At Rocky Ford there was very little difference. In over-all comparisons of females on the same basis, excluding FC 601, there is some indication that SP 602116sl x FC 502/2 has special merit and deserves additional trials. This conclusion is in line with results obtained at Fort Collins (Tables 4 and 8) where the gross sucrose average for all hybrids of SP 602116sl x FC 502/2 (i.e. e x j) was 4806 pounds per acre compared with 4507 for the two accessions of the standard variety, SL (129 x 133) x SP 6322-0. In this connection, it is noteworthy that (SP 602116sl x FC 502/2) x SP 5822-0 was highest in average gross sucrose yield among all entries listed in Table 13.

Table 13 .--Summary of harvest results of cooperators' agronomic evaluation tests of monogerm, LSR-BRR, top-cross hybrids, as percent of the standard variety, SL (129 x 133) MS x SP 6322-0; Rocky Ford, Colorado, and East Grand Forks, Minnesota, 1966.

Description ^{a/}	Seed no.	Gross suc. yield:	Root yield	Sucrose percent						
Location		R. F.:E.G.F:Aver.:R. F.:E.G.F:Aver.:R. F.:E.G.F:Aver.:								
Disease exposure ^{b/}		IS-1 :IS-1 : :IS-1 :IS-1 : :IS-1 :IS-1 :								
		CT-1 : : :CT-1 : : :CT-1 : : :								
No. of replications		6 : 8 : : 6 : 8 : : 6 : 8 : :								
L S D (.05)		17 : 10 : : 15 : 9 : : 6 : 4 : :								
(SP 602116s1 x FC 502/2) x SP 5822-0	SP 651201H013	123	89	106.0	116	87	101.5	106	101	103.5
(SP 602105s1 x ") x "	H014	101	88	94.5	98	88	93.0	104	101	102.5
(FC 505 x SP 581181s1) x "	H022	107	90	98.5	102	92	97.0	105	97	101.0
(FC 502/2 x SP 581181s1) x "	H024	102	85	93.5	92	83	87.5	110	102	106.0
(" " x FC 505)	H028	103	79	91.0	92	77	84.5	112	103	107.5
Average		107.2	86.2	96.7	100.0	85.4	92.7	107.4	100.8	104.1
(SP 602116s1 x FC 502/2) x SP 59B18-0	SP 651202H013	109	83	96.0	100	80	90.0	109	104	106.5
(SP 602105s1 x ") x "	H014	88	76	82.0	82	75	78.5	108	102	105.0
(FC 505 x SP 581181s1) x "	H022	107	91	99.0	99	89	94.0	107	103	105.0
(FC 502/2 x SP 581181s1) x "	H024	106	81	93.5	94	77	85.5	112	104	108.0
(" " x FC 505)	H028	86	73	79.5	78	71	74.5	111	103	107.0
Average		99.2	80.8	90.0	90.6	78.4	84.5	109.4	103.2	106.3
(SP 602116s1 x FC 502/2) ♀	Aver.	H013	116.0	86.0	101.0	108.0	83.5	95.8	107.5	102.5
(SP 602105s1 x " ") ♀	"	H014	94.5	82.0	88.3	90.0	81.5	85.8	106.0	101.5
(FC 505 x SP 581181s1) ♀	"	H022	107.0	90.5	98.8	100.5	90.5	95.5	106.0	100.0
(FC 502/2 x SP 581181s1) ♀	"	H024	104.0	83.0	93.5	93.0	80.0	86.5	111.0	103.0
(" " x FC 505) ♀	"	H028	94.5	76.0	85.3	85.0	74.0	79.5	111.5	103.0
Furnished by cooperator:										
Local check, Am #2 (60-806-0)		104		88		92		113		
" , Am #3 S, monogerm						91			97	
62-GH #2-1-0		99				86		115		
SP 6322-0 x SLC 129		114				116		98		
T22-H7		108				107		101		

^{a/} Cytoplasmic male sterility was utilized to enforce hybridization in the production of all SP 651201 and SP 651202 material.

^{b/} Disease exposure: LS = Cercospora leaf spot; CT = curly top; 1 = mild; 2 = moderate; 3 = severe.

a/ Cytoplasmic male sterility was utilized to enforce hybridization in the production of all SP 651203 and SP 651204 material.

b/ Disease exposure: LS = Cercospora leaf spot; CT = curly top; Rh = Rhizoctonia root or crown rot;
1 = mild; 2 = moderate; 3 = severe.

Evaluation of Miscellaneous Material

A number of hybrids, varieties, etc., from various sources were compared in an agronomic test (Exp. 4A) under severe leaf spot exposure at Fort Collins. Several of the entries also were tested for curly top resistance at Thatcher, Utah, by A. M. Murphy. Descriptions of entries and techniques are presented in Table 15 together with the summarized results.

Two accessions of the standard variety, SL (129 x 133) x SP 6322-0 (i.e. entries 179 and 180), were included in the test. Only two entries significantly exceeded the standard variety in gross sucrose yield. One of them, FC (502/2 x 503) x FC 901 (entry 176), is now considered rather unattractive because of imperfections in FC 503. The other, FC (502/2 x 504) x FC 901 (entry 177) is of special interest, currently, and its performance was superior in other tests at Fort Collins in 1966 (Tables 2 and 8). In Experiment 4A (Table 15), that hybrid significantly exceeded the standard variety in sucrose percentage as well as in gross sucrose yield. Its root yield also was higher than that of the standard, but the difference was not significant.

Two triploid hybrids (entries 172 and 173), involving a pool of Savitsky tetraploids as a parent, were included in the test; also four Polish varieties presumed to be of polyploid character (entries 193-196). None of these six entries was substantially above the standard variety in gross sucrose yield, and two of the Polish varieties were much lower. None of the Polish varieties was more leaf spot resistant than the standard variety, and two apparently were more susceptible.

Table 15 --Agronomic and disease resistance evaluation of miscellaneous sugarbeet material, Fort Collins, Colorado, and Thatcher, Utah, 1966.

Description	Fort Collins ^{a/}										Fort Collins Exp. 4-A (8-plot averages) ^{b/}										Thatcher ^{c/}		
	General	Seed type	C.T. g./res.	or	Wettsville	seed no.	no.	Gross	Acres	Yield	Tons	Z	8/18	8/26	8/12	100'	Plants	Bolt.	C.T. h/	grade			
Pool of S-64-15, -22, & -29 (4A, V.F.S.)		M	+	SP 651212100				171	3830	12.55	15.25	3.88	3.63	4.50	119	0.0	6.0						
FC (502 x 503) MS x S-64 pool		m	+	" " H01				172	4697	15.04	15.61	3.50	3.63	5.75	117	0.0	6.5						
(SP 602105sl x FC 505) MS x S-64 pool		m	+	" " H02				173	4508	14.57	15.44	3.38	3.63	5.25	123	0.0	7.0						
FC (502 x 503) MS x FC 901		m	+	" 651203H011				174	4639	14.56	15.92	4.13	4.38	6.00	122	0.0	7.5						
(SP 602105sl x FC 505) MS x FC 901		m	+	" " H026				175	4147	12.81	16.18	4.38	4.38	5.38	118	0.0	6.5						
FC (502/2 x 503) MS x FC 901		m	+	" 641204H01				176	5153	15.88	16.22	3.38	3.75	6.00	117	0.0							
FC (502/2 x 504) MS x FC 901		m	+	" " H03				177	5122	16.15	15.84	3.50	3.75	5.75	118	0.0							
F63-648H3 MS x SP 631225-02		m	+	" 651216H01				178	4044	13.11	15.37	4.00	4.25	5.50	117	0.0							
SL (129 x 133) MS x SP 6322-0		m	+	Acc. 2636				179	4665	15.18	15.29	4.25	4.25	5.88	120	0.5							
do.		m	+	" 2646				180	4541	15.05	15.07	4.38	4.75	5.63	116	0.0	7.0						
GW 674-56C		M	-	" 2168				181	4426	14.63	15.15	4.13	4.75	6.00	120	1.2							
Rhizoc. res. sel. from GW 674-56C		M	-	SP 631001-0				182	4844	16.56	14.63	4.13	4.63	6.00	117	3.6							
SP 6510-0; from Coe (last CTR sel. by Murphy)		M	+	Acc. 2649				183	3142	10.40	15.12	4.50	4.50	5.00	114	0.0							
SL (126 x 129)		m	+	SP 6428-0				184	4231	13.73	15.39	4.38	4.50	6.00	118	0.0							
SL 126		m	+	" " x 021				185	4099	13.58	15.08	4.38	4.50	5.63	120	0.0							
SL 129		m	+	" " x 022				186	4052	13.04	15.52	4.25	4.25	5.75	117	0.0							
SL 133		m	+	" " x 023				187	4727	15.00	15.71	3.88	4.13	5.63	117	0.0							
SL (129 x 133)		m	+	" " x 029				188	4566	14.58	15.64	4.00	4.25	5.63	120	0.0							
(SL 126 x SP 6121-0)		m	+	" " x 030				189	4365	14.19	15.36	3.38	3.75	6.00	119	0.5							
(SL 129 x ")		m	+	" " x 031				190	4223	13.76	15.34	3.88	3.88	5.88	117	0.0							
(CT 5 x ")		m	+	" " x 033				191	4175	13.74	15.16	3.75	4.00	5.88	118	0.6							
(CT 5 x SL 129)		m	+	" " x 034				192	4196	13.83	15.11	4.25	4.38	5.75	117	0.0							
Buszczyński P-Poly (Poland)		M	-	Acc. 2650				193	3703	12.61	14.64	4.63	4.75	5.25	115	0.0							
Tetra-Tri-Polanowice, Pol-0 (")		M	-	" 2651				194	4506	14.31	15.74	4.38	4.38	5.75	116	0.0							
AJ Poli 2 (")		M	-	" 2652				195	4590	14.79	15.55	4.38	5.00	6.00	115	0.0							
Poly-Nono, Poli (")		M & m	-	" 2653				196	3300	12.12	13.44	4.88	5.00	5.25	119	0.0							
SP 5481-0		M	-	" 2483																			
" 6051-0		M	+	SP 631210H0																			8.5
US 33		M	+																				6.5
US 41		M	+																				7.3
General mean																							6.0
S.E. of entry mean																							
S.E. " " " as % of gen. mean																							
L.S.D. (.05)																							
F																							

- a/ Seed numbers involving "SP 6528" are Wetsville, Wd., numbers; all others were assigned at Ft. Collins.
- b/ Plots 1 row x 20'; randomized block design; leaf spot exposure intensified artificially.
- c/ Results at Thatcher (furnished by A. M. Murphy) were based on a minimum of two plots (1 row x 50' in size) for each entry or variety; curly top exposure intensified artificially.
- d/ Seed type: M = multigerm; m = monogerm.
- e/ Curly top resistance (based on previous experience or breeding history): + = resistant (though varying widely in degree); - = susceptible.
- f/ Leaf spot grades (K. G. Gould): 0 = no leaf spot; 10 = complete defoliation.
- g/ Foliage vigor (K. G. Gould): larger no. = greater vigor.
- h/ Curly top grades (A. M. Murphy): 0 = healthy; 9 = death due to curly top.

Bolting Resistance Selection and Evaluation

Because of increasing interest in and need for LSR-CTR material having bolting resistance, an attempt was initiated in 1964 to extract bolting resistant lines from FC 901. Seed was planted in a warm greenhouse on September 15. On October 6 the plants were placed in an induction room which was illuminated continuously with standard cool white fluorescent lamps and held at about 7 or 8° C (1). After varying lengths of induction treatment, the plants were returned to the warm greenhouse where they were illuminated continuously. The artificial light provided there (at night) was furnished by incandescent lamps. Bolters were rogued, and the nonbolters were returned to the induction room on January 19, 1965. A summary of induction timing, sizes of populations, and numbers of bolters rogued is as follows:

1964 code no.	: Induction : time	: Plants to : G.H. after : induction	: <u>Plants rogued</u> : Bolters	: Other : (small)	: Nonbolters : reinduced
	<u>Weeks</u>	<u>No.</u>	<u>No.</u>	<u>No.</u>	<u>No.</u>
264	4	84	79	0	5
265	6	175	169	1	5
266	8	262	259	0	3

After a reinduction period of 14 weeks, the nonbolters were permitted to flower and interpollinate in a polyethylene enclosure in the greenhouse. Each male-fertile plant was selfed by means of one paper bag. Since FC 901 is rather highly self fertile, much of the seed produced outside the bags was presumed to be a product of selfing. The seed produced outside the bags was harvested separately from each plant; also the seed inside the bags.

Evaluation techniques and the summarized results (Exp. 7A and greenhouse) are presented in Table 16. From these results it was concluded that the selection procedure described above was highly successful in extracting bolting resistant genotypes from FC 901. The actual level of bolting resistance achieved will not be known until field comparisons can be made under currently accepted field practices at Salinas, Calif. It is gratifying to note that one of the bolting resistant progenies, SP 651101-3, apparently is quite high in leaf spot resistance.

Table 16 ---Bolting and leaf spot resistance evaluation of lines resulting from bolting resistance selection in the LSR-CTR line, FC 901; Fort Collins, Colorado, 1966.

Source and/or description	Fort Collins seed no.	a/ : Bolter comparisons			d/ : Field Exp. no. 7A			
		1966: Plants b/	Bolt c/	Entry: Leaf spot e/	Vigor f/	8/22:	9/10:	8/15 :
		no. : induced	ers	no. :				
		No.	No.					
FC 901; 1964 code no. 264	SP 651101c1	112	16	2				
" " " " " "	" " -1	113	16	0	361	4.5	6.5	5.0
" " " " " "	" " -2	114	16	4	362	4.0	4.3	5.5
" " " " " "	" " c3	115	16	0				
" " " " " "	" " -3	116	16	0	363	2.0	1.8	5.0
" " " " " "	" " -4	117	16	9	364	3.0	4.0	5.0
" " " " " 265	" " c5	118	16	0				
" " " " " "	" " -5	119	16	2	365	3.5	3.8	5.0
" " " " " "	" " c6	120	16	1				
" " " " " "	" " -6	121	16	1	366	4.0	4.0	5.0
" " " " " "	" " c7	122	16	6				
" " " " " "	" " -7	123	16	6	367	2.0	1.5	6.0
" " " " " "	" " c8	124	16	14				
" " " " " "	" " -8	125	16	9	368	4.0	5.5	4.0
" " " " " "	" " -9	126	16	4	369	4.0	3.8	6.0
" " " " " 266	" " c10	127	16	3				
" " " " " "	" " -10	128	16	2	370	4.0	4.0	5.0
" " " " " "	" " -11	129	16	1	371	3.5	4.0	5.0
" " " " " "	" " c12	130	16	5				
" " " " " "	" " -12	131	16	5	372	4.0	4.5	5.0
FC 901 (sibs and selfs)	SP 651100+0A	135	16	15	373	3.5	3.8	5.5
FC 901 (all sibs)	" " -0B				374	3.5	3.0	6.0
GW 674-56C	Acc. 2168	136	16	14				
SP 5822-0	Acc. 2644	137	16	15				
SP 5822-0	Acc. 2591				376	2.0	1.5	6.0
US H7	Acc. 2645	138	16	4				
663 (McFarlane)	SP 651204H0	139	16	3				
SP 5481-0	Acc. 2483				375	3.0	3.3	6.0
Syn. check (Europ.)	Acc. 2269				377	4.0	5.0	6.0

a/ Each suffix number in the SP 651101 material (e.g. 1, 2, 3, etc.) represents an individual parental plant. The letter "c", preceding the suffix no., indicates selfing, and a dash (-) indicates open-pollination.

b/ Six weeks' induction at about 7 or 8° C with continuous illumination (standard cool white fluorescent lamps and no sunlight), after a 3-week start in greenhouse.

c/ In greenhouse, under favorable (warm) growing conditions and continuous illumination (incandescent lamps used at night).

d/ Plots 2 rows x 12'; 2 replications; inoculation and frequent sprinkling used to promote development of leaf spot.

e/ Leaf spot grades (K. G. Gould on 8/22; J. O. Gaskill on 9/10): 0 = no leaf spot; 10 = complete defoliation.

f/ Foliage vigor (K. G. Gould): larger no. = greater vigor.

Cooperative Evaluation Tests of LSR-CTR Varieties

Seed supplies of sugarbeet hybrids and varieties, assigned entry numbers 1 through 7 (Table 17), were assembled at Fort Collins and distributed to cooperators for evaluation. Tests at three locations were abandoned or disregarded because of loss of stand or other misfortunes. The others were as follows:

State :	Locality	Type ^{a/}	Agency conducting test :	Table	:Fig.:
Calif.	Gerber	A	Holly Sugar Corp.	21(a) & (b)	
Colo.	Fort Collins	A	U. S. Dept. of Agr.	22	" " "
"	Rocky Ford	A	Amer. Crystal Sug. Co.	23	" " "
"	Sugar City	A	National Sug. Mfg. Co.	24	" " "
Iowa	Kanawha	A	Amer. Crystal Sug. Co.	25	" " "
"	Mason City	A	" " " "	26	" " "
Kan.	Tribune	A	Kan. Agr. Exp. Sta. & Nat'l. Sug. Mfg. Co.	27	" " "
Md.	Beltsville	A	U. S. Dept. of Agr.	28	" " "
Minn.	Crookston	A	Amer. Crystal Sug. Co.	29	" " "
N.M.	Artesia	A	N. M. Agr. Exp. Sta.	30	" " "
Okla.	Goodwell	A	Okla. Agr. Exp. Sta.	31	" " "
Texas	Hereford	A	Holly Sugar Corp.	32	" " " 3
Utah	Logan	O	U. S. Dept. of Agr.	33	
"	Thatcher	O	" " " " "	33	

^{a/} Type of test: A = agronomic; O = observational.

Curly top exposure was extremely severe at Hereford, Texas, where the leaf spot resistant (curly top susceptible) check, entry 6, yielded 2.9 tons of roots per acre in contrast with a yield of 20.6 tons for the curly top resistant check, entry 7. Curly top exposure was quite severe at Artesia, N. M., moderately severe at Goodwell, Okla., and mild or negligible in all other agronomic tests. Severe leaf spot conditions occurred naturally at Hereford, Artesia, and Goodwell. Moderately severe and severe leaf spot epidemics were developed with the aid of artificial techniques at Beltsville, Maryland, and Fort Collins, Colorado, respectively. The disease was mild or negligible in the other agronomic tests. The two observational tests in Utah were designed specifically for curly top resistance evaluation, and severe curly top exposure was provided artificially in each of those tests.

Results for the individual tests are presented in the tables and figure listed above. A general summary of disease conditions and harvest results for all of the agronomic tests is given in Tables 18, 19, and 20. Because of the wide range in the severity of leaf spot and curly top exposures at the respective locations, average performance figures for the LSR check (entry 6) and the CTR check (entry 7) mean little. The high light among the other general averages is the outstanding position of entry 1, SL (129 x 133) x SP 6322-0, in gross sucrose yield. The high gross sucrose yield of the variety in these tests was in keeping with its gross sucrose performance in the 1965 cooperative tests (2) where it placed a "close second" to FC (502/2 x 504) x FC 901. The latter variety did not occur in the 1966 cooperative tests. The high gross sucrose yield of entry 1 in 1966 was due to its high root yield. However, the sucrose percentage of that variety was considered satisfactory. The only variety that exceeded entry 1 substantially in sucrose percentage was entry 4, FC (502 x 503) x FC 901, but the outstanding sucrose percentage of that variety was more than offset by its lower root yield, and the gross sucrose yield of entry 4 was 95.7 percent of that of entry 1.

Although the over-all performance of entry 1 was gratifying, it is important to recognize that its resistance to leaf spot and curly top is approximately intermediate between that of resistant and susceptible lines, and that higher levels of resistance to both diseases are urgently needed in areas where both diseases are serious problems. The severe impact of these diseases in the Hereford area, particularly, in 1966 emphasized this point. In this connection it should be noted that the root yield of the curly top resistant check (entry 7, US H7) in the Hereford test was 144 percent of that of entry 1. Its outstanding yield in that test is attributed largely to its high level of curly top resistance. However, its susceptibility to leaf spot is a serious handicap and presumably was responsible, at least in part, for its relatively low sucrose percentage in the Hereford test--i.e. 91% of that of entry 1.

Literature Cited

- (1) Gaskill, John O. 1963. Comparison of fluorescent and incandescent lamps for promotion of flowering in sugar beet seedlings. J. Am. Soc. Sugar Beet Technol. 12(7): 623-634.
- (2) Gaskill, John O., et al. Development and evaluation of sugarbeet breeding material and varieties carrying resistance to leaf spot and curly top, 1965. Sugarbeet Research, 1965 Report (Crops Research Division, A.R.S., U.S.D.A.). CR-4-66 pp. 173-229.

Note: Results of a study of varietal response of sugarbeets to post-emergence herbicide applications are presented as a supplement to this report on page 256.

Table 17 .--Description of material in cooperative agronomic evaluation tests of LSR-CTR varieties, 1966. a/

Entry: Fort Collins :		Description and supplier <u>b/</u>	:
no. :	seed no. :		:
1	Acc. 2646	SL (129 x 133) MS x SP 6322-0; monogerm; LSR-CTR-BRR; Farmers and Manufacturers Beet Sugar Assoc. (Mich. Sug. Co. lot no. 628446).	
2	Acc. 2647	SP 6528X030 [(SL 126 x SP 6121-0)MS x SP 6428-0]; LSR-CTR-BRR; monogerm; G. E. Coe, U.S.D.A., Beltsville, Maryland.	
3	Acc. 2648	SP 6528X031 [(SL 129 x SP 6121-0)MS x SP 6428-0]; LSR-CTR-BRR; monogerm; G. E. Coe, U.S.D.A., Beltsville, Maryland.	
4	SP 651203H011	FC (502 x 503) MS x FC 901; LSR-CTR; monogerm; U.S.D.A., Fort Collins, Colorado.	
5	SP 651213H01	(SL 129 x McF. 2648) MS x SP 6051-0; LSR-CTR; monogerm; U.S.D.A., Fort Collins, Colorado.	
6	Acc. 2644	SP 5822-0 (LSR check); LSR-BRR; multigerm; F & M and West Coast Beet Seed Co. (WC lot no. 3378).	
7	Acc. 2645	US H7 (CTR check); monogerm; CTR and bolting resistant; J. S. McFarlane, U.S.D.A., Salinas, California.	

a/ At least one local check, furnished by the cooperator, was included in each test in addition to the varieties listed in this table.

b/ Disease resistance, though varying widely in degree, is indicated by symbols, above, as follows: BRR = black root resistant (i.e. resistant to the Aphanomyces type black root); CTR = curly top resistant; LSR = leaf spot resistant.

Table 18 .--General summary of harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1966; as percent of the standard variety, SL (129 x 133) MS x SP 6322-0.

Gross Sucrose Yield														
Location	Diseases ^{a/}	No. : :reps.:	Entry no.					Local ck. ^{b/} :LSD ^{c/} : a : b : (.05)						
			1	2	3	4	5	6	7					
(1) Gerber, Calif.		8	100	98	96	99	99	84	95	103			10	
(2) Ft. Collins, Colo.	LS-3	9	100	81	83	95	80	85	77	93			77	7
(3) Rocky Ford, Colo.	LS-1, CT-1	12	100	103	101	103	91	77	91	95			92	14
(4) Sugar City, Colo.	CT-1	9	100	99	99	102	95	90	104	94			104	12
(5) Tribune, Kan.		9	100	95	92	105	94	96	114	101				9
(6) Goodwell, Okla.	LS-3, CT-2	10	100	95	90	104	93	71	89	99				13
(7) Hereford, Texas	LS-3, CT-3+, Rh-1	9	100	69	63	92	117	20	131	82			96	12
(8) Artesia, N.M. d/	LS-3, CT-3+	4	100	79	87	95	97	37	113	89			107	19
(9) Crookston, Minn.	LS-1	9	100	100	108	92	90	84	106	109			114	10
(10) Mason City, Ia.	LS-1	9	100	107	80	83	100	77	105	89				19
(11) Kanawha, Ia.	LS-1, BR-1	9	100	104	85	83	84	83	81	87			86	15
(12) Beltsville, Md.	LS-2, BR-1	3	100	99	95	95	79	101	62	103				11
Average			100.0	94.1	89.9	95.7	93.3	75.4	97.3	95.3				

^{a/} Disease exposure: BR = black root (*Aphanomyces cohlloides*); CT = curly top (virus); LS = leaf spot (*Cercospora beticola*); Rh = *Rhizoctonia* root or crown rot; 1 = mild; 2 = moderate; 3 = severe.

^{b/} Local checks, a and b, were as follows, respectively (location numbers in parentheses): (1) HH 9; (2) GW 674-56C and SL (126 x 128) x SP 5822-0; (3) Am #2 mono and Am #3-N; (4) SL (126 x 128) x SP 5822-0 and National Blend; (5) SL (126 x 128) x SP 5822-0; (6) HH 10; (7) HH 10 and 42108-08; (8) HH 10 and 42108-08; (9) Am #3-S mono and T14-H11; (10) Am #3-S mono; (11) Am #3-S mono and T22-H7; (12) SP 64194-0.

^{c/} LSD (.05) expressed as percent of the gross sucrose yield of the standard variety.

^{d/} Results shown for Artesia, N.M., are gross soluble solids, not gross sucrose.

Table 10. General summary of harvest results, comparative agronomic evaluation tests of LSK-616 varieties, 1966; as percent of the standard variety, SL (126 x 128) MS x SP 5822-0.

Location	Diseases ^{a/}	No. : : reps.	Entry no.										Local ck. b/		LSD ^{c/} : (.05)
			1	2	3	4	5	6	7	8	9	a	b		
Foot yield															
(1) Gerber, Calif.		8	100	100	92	99	99	83	95	104					8
(2) Ft. Collins, Colo.	LS-3	9	100	83	85	92	81	86	83	93				79	6
(3) Rocky Ford, Colo.	LS-1, CT-1	12	100	103	98	96	90	75	90	86				93	13
(4) Sugar City, Colo.	CT-1	9	100	93	100	101	94	90	107	96				104	12
(5) Tribune, Kan.		9	100	93	91	101	92	34	113	100					8
(6) Goodwell, Okla.	LS-3, CT-2	10	100	86	87	96	93	65	95	99					9
(7) Hereford, Texas	LS-3, CT-3+, Rh-1	9	100	71	64	92	122	20	144	89				99	12
(8) Artesia, N.M.	LS-3, CT-3+	4	100	77	83	90	95	38	112	85				105	16
(9) Crookston, Minn.	LS-1	9	100	101	108	88	85	88	103	107				111	9
(10) Mason City, Ia.	LS-1	9	100	110	79	81	101	77	110	88					19
(11) Kanawha, Ia.	LS-1, BR-1	9	100	106	85	82	84	84	80	87				86	15
(12) Beltsville, Md.	LS-2, BR-1	3	100	97	94	91	82	94	77	101					14
Average			100.0	93.8	88.8	92.4	93.2	74.5	100.8	94.6					

^{a/} Disease exposure: BR = black root (*Aphanomyces cohlloides*); CT = curly top (virus); LS = leaf spot (*Cercospora beticola*); Rh = *Rhizoctonia* root or crown rot; 1 = mild; 2 = moderate; 3 = severe.

^{b/} Local checks, a and b, were as follows, respectively (location numbers in parentheses): (1) HH 9; (2) GW 674-56C and SL (126 x 128) x SP 5822-0; (3) Am #2mono and Am #3-N; (4) SL (126 x 128) x SP 5822-0 and National Blend; (5) SL (126 x 128) x SP 5822-0; (6) HH 10; (7) HH 10 and 42108-08; (8) HH 10 and 42108-08; (9) Am #3-S mono and TL4-H11; (10) Am #3-S mono; (11) Am #3-S mono and T22-H7; (12) SP 64194-0.

^{c/} LSD (.05) expressed as percent of the root yield of the standard variety.

Table 20 --General summary of harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1966; as percent of the standard variety, SL (129 x 133) MS x SP 6322-0.

Sucrose Percentage														
Location	Diseases ^{a/}	No. :	Entry no.										Local ck. b/ : LSD ^{c/}	
			: reps.:										: a : b : (.05)	
			1	2	3	4	5	6	7	a	b			
(1) Gerber, Calif.		8	100	98	105	100	100	100	100	99			5	
(2) Ft. Collins, Colo. LS-3		9	100	97	97	102	98	98	92	100	97		2	
(3) Rocky Ford, Colo. LS-1, CT-1		12	100	100	103	107	100	103	100	111	99		4	
(4) Sugar City, Colo. CT-1		9	100	100	99	101	101	101	98	99	100		3	
(5) Tribune, Kan.		9	100	103	101	104	102	102	101	102			4	
(6) Goodwell, Okla. LS-3, CT-2		10	100	110	104	109	103	109	97	102			8	
(7) Hereford, Texas LS-3, CT-3+, Rh-1		9	100	97	98	101	95	97	91	92	97		4	
(8) Artesia, N.M. d/ LS-3, CT-3+		4	100	102	105	106	102	99	101	105	101		10	
(9) Crookston, Minn. LS-1		9	100	99	100	105	106	96	103	102	103		4	
(10) Mason City, Ia. LS-1		9	100	97	101	102	100	100	95	101			3	
(11) Kanawha, Ia. LS-1, BR-1		9	100	98	100	102	100	99	101	100	100		4	
(12) Beltsville, Md. LS-2, BR-1		3	100	102	101	104	97	108	81	102			4	
Average			100.0	100.3	101.2	103.6	100.3	101.0	96.7	101.3				

a/ Disease exposure: BR = black root (Aphanomyces cochlidioides); CT = curly top (virus); LS = leaf spot (Cercospora beticola); Rh = Rhizoctonia root or crown rot; 1 = mild; 2 = moderate; 3 = severe.

b/ Local checks, a and b, were as follows, respectively (location numbers in parentheses): (1) HH 9; (2) GW 674-56C and SL (126 x 128) x SP 5822-0; (3) Am #2 mono and Am #3-N; (4) SL (126 x 128) x SP 5822-0 and National Blend; (5) SL (126 x 128) x SP 5822-0; (6) HH 10; (7) HH 10 and 42108-08; (8) HH 10 and 42108-08; (9) Am #3-S mono and T14-H11; (10) Am #3-S mono; (11) Am #3-S mono and T22-H7; (12) SP 64194-0.

c/ LSD (.05) expressed as percent of the sucrose percentage of the standard variety.

d/ Results shown for Artesia, N.M., are refractometer determinations, not sucrose.

Table 21(a) .--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Gerber, California, 1966.

Conducted by: Alex Lange and D. D. Dickenson.

Location: S. D. Glatz Ranch, Gerber, California.

Cooperation: Holly Sugar Corporation and S. D. Glatz.

Dates of Planting and Harvest: April 12; October 6.

Experimental Design: Latin Square, 8 x 8, but analyzed as randomized block experiment due to actual field layout; plots 2 rows x 53'; rows 30" apart.

Root Yield Determination: Two rows x 50' in each plot.

Sucrose Determination: Two 25# samples per plot.

Stand Counts: Actual number of beets at harvest.

Leaf Spot Exposure: None.

Curly Top Exposure: None.

Other Diseases: Only an occasional rotted beet.

Soil and Seasonal Conditions: Excellent growing season, but not all available nitrogen was used by the crop.

Reliability of Test: Good.

Table 21(b) --Results of cooperative agronomic evaluation test of LSR-CTR varieties, Gerber, California, 1966 (8-plot averages).

Description	: Ft. Collins : seed no.	: Entry : no.	: Acre Yield :		: Beets : per : row
			Lbs.	Tons	
					No.
SL (129 x 133) x SP 6322-0	Acc. 2646	1	8402	28.309	14.84
(SL 126 x SP 6121-0) x SP 6428-0	Acc. 2647	2	8237	28.190	14.61
(SL 129 x SP 6121-0) x SP 6428-0	Acc. 2648	3	8060	25.917	15.55
FC (502 x 503) x FC 901	SP 651203H011	4	8311	27.909	14.89
(SL 129 x 2648) x SP 6051-0	SP 651213H01	5	8352	28.007	14.91
SP 5822-0 (LSR check)	Acc. 2644	6	7043	23.633	14.90
US H7 (CTR check)	Acc. 2645	7	7984	26.863	14.86
HH 9 (Local Check)		8	8646	29.530	14.64
General Mean			8129	27.295	14.90
S.E. mean			287 ^{a/}	.821	.277
LSD (5%)			816	2.33	.788
SEM/gen. mean (%)			3.54	3.01	1.86

Variance Table

Variation due to:D/F:		Mean square
Tons beets : Percent Sucrose :		
Variety	7 26.51428	.66250
Replications	7 157.67703	5.00964
Error	49 5.38942	.61581
Total	63	
Calculated F	4.92**	1.08NS

^{a/} Short cut formula.

** Exceeds 1% level of 3.04.

NS Not significant.

Table 22(a) .--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Fort Collins, Colorado, 1966 (Exp. no. 1A).

Conducted by: J. O. Gaskill and L. W. Lawson.

Location: Hospital Farm, Fort Collins, Colorado; Field no. 3.

Cooperation: Colorado Agricultural Experiment Station, Beet Sugar Development Foundation, and National Sugar Manufacturing Company.

Dates of Planting and Harvest: April 29; October 25.

Experimental Design: Latin Square, 9 x 9; plots 2 rows x 20'; rows 20" apart; hand thinned to single-plant hills.

Determination of Root Yield: All roots in an accurately measured area (usually at least 30 ft. of row) in each plot were topped, washed, and weighed.

Determination of Sucrose and Purity Percentages: All roots harvested for yield determination in each plot were divided into 2 samples for sucrose and purity analyses. Sucrose analyses were made in duplicate for each root sample.

Stand and Bolter Counts: For stand, all plants in the area to be harvested in each plot were counted just before harvest. Bolter percentages were determined by counts (entire plots) in mid-season, and seed stalks were cut off at that time.

Recent Cropping History: 1962, sugarbeets; 1963-65, barley.

Chemicals Applied for 1966 Crop: Treble superphosphate (approx. 112 lbs. P₂ O₅ per acre) and ammonium nitrate (about 74 lbs. of N per acre) were applied and disced in just before plowing in August, 1965. Additional ammonium nitrate (approx. 38 lbs. of N per acre) was applied on March 21, 1966. Shell DD (about 41 gal. per acre) was chiseled in after plowing in August, 1965, for control of the sugarbeet nematode.

Leaf Spot Exposure: Severe.

Curly Top Exposure: Negligible.

Other Diseases and Pests: Rhizoctonia caused moderate stand losses in the latter part of the season. Areas where plants were killed by Rhizoctonia, in any given plot, were excluded from the area harvested for yield and laboratory analyses. Effects of western yellows and sugarbeet nematode were mild.

Soil and Seasonal Conditions: The 1966 crop season was hot and dry. Adequate soil moisture was provided artificially throughout the season as needed, principally by furrow irrigation. Inoculation (July 5) and subsequent frequent sprinkling were used to promote the development of leaf spot (Cercospora beticola).

Reliability of Test: Very good.

Table 22(b) .--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Fort Collins, Colorado, 1966 (Exp. 1A, 9-plot averages).

Description	:Fort Collins :		Entry :		Acres yield :		Appar--:		Thin :		Leaf spot ^{a/} :		Vigor ^{b/} :		Stand :		Bolt-ers :	
	seed	no.	no.	no.	Gross :	Sucrose:	ent :	juice:	ent :	juice:	8/22:8/30 :	8/15 :	8/15 :	per 100':	No.	%		
					Lbs.	Tons	%	%	%	%								
SL (129 x 133) x SP 6322-0	Acc. 2646	1	5143	16.20	15.91	88.46	95.18	4.0	4.3	6.0	118	0.00						
(SL 126 x SP 6121-0) x SP 6428-0	Acc. 2647	2	4160	13.48	15.41	87.62	95.41	3.9	4.0	6.0	117	0.51						
(SL 129 x SP 6121-0) x SP 6428-0	Acc. 2648	3	4255	13.71	15.50	87.89	95.72	4.0	4.0	6.0	116	0.27						
FC (502 x 503) x FC 901	SP 651203H011	4	4865	14.97	16.26	89.02	95.64	3.9	4.0	6.0	117	0.61						
(SL 129 x 2648) x SP 6051-0	SP 651213H01	5	4092	13.09	15.61	89.25	95.29	4.3	4.3	6.0	117	0.00						
SP 5822-0 (LSR check)	Acc. 2644	6	4359	13.94	15.61	87.76	95.83	3.0	3.9	6.0	116	0.00						
US H7 (CTR check)	Acc. 2645	7	3935	13.44	14.63	87.83	94.42	5.3	5.3	5.0	119	0.00						
GW 674-56C (Local check)	Acc. 2168	8	4762	15.01	15.85	87.62	94.42	3.9	4.6	6.0	118	0.26						
SL (126 x 128)x SP 5822-0(Loc.ck.)	Acc. 2642	9	3958	12.82	15.42	88.78	95.62	4.4	4.6	6.0	121	0.00						
General mean			4392	14.07	15.58	88.25	95.28	4.09	4.33		117.61							
S. E. of var. mean			123.23	0.36	0.13	0.37	0.28	0.12	0.13		1.40							
S. E. of var. mean as % of gen. mean			2.81	2.57	0.85	0.42	0.30	3.02	2.95		1.19							
L. S. D. (.05)			349	1.02	0.37	1.05	0.80	0.35	0.36		3.96							

Variance Table

: :		Mean square (variance)	
Source of variation:	D/F:	Gross sucrose:	Roots :Sucrose %:App. pur.:T.J. pur.:L.S. 8/22:L.S. 8/30: Stand
Rows	8	157,532	2.23 0.676 3.433 0.855 0.133 0.139 183.81
Columns	8	762,282	4.98 0.773 1.160 4.485 0.271 0.250 48.22
Varieties	8	1,671,342	10.85 1.811 3.690 2.551 3.439 1.834 20.82
Error (remainder)	56	136,669	1.18 0.158 1.251 0.719 0.137 0.147 17.68
Total	80		
Calculated F value		12.23**	9.19** 11.50** 2.95** 3.55** 25.15** 12.49** 1.18

a/ Leaf spot readings (K. G. Gould): 0 = no leaf spot; 10 = complete defoliation.

b/ Foliage vigor: Larger number = greater vigor.

** F exceeds the 1% point.

Table 23(a) .--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Rocky Ford, Colorado, 1966.

Conducted By: American Crystal Sugar Company.

Location: Rocky Ford, Colorado.

Dates of Planting and Harvest: April 5, October 26.

Experimental Design: 9 varieties in 3 x 3 balanced lattice. Composite of three such tests. 12 replications.

Determination of Root Yield: Weight of all beets harvested per plot.

Determination of Sucrose Percentage: All harvested beets used in two samples.

Stand Counts: Harvested beets counted when weighed.

Leaf Spot Exposure: Very light.

Curly Top Exposure: Very light.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: Good seasonal conditions.

Reliability of Test: Highly reliable for sucrose percent, but due to soil conditions, not a precise test for tonnage. One low variety made the test significant.

Table 23(b) .--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Rocky Ford, Colorado, 1966 (Composite averages of 12 plots).

Description	:		:		:		:		:		:	
	: Ft. Collins		: Entry		: Gross		: Roots		: Sucrose		: Stand	
	: seed no.		: no.		: sucrose:		: Tons		: %		: (Roots	
					Lbs.						per 35')	
											No.	
SL (129 x 133) x SP 6322-0	Acc. 2646		1		5905		20.88		14.14		43.8	
(SL 126 x SP 6121-0) x SP 6428-0	Acc. 2647		2		6089		21.50		14.16		46.6	
(SL 129 x SP 6121-0) x SP 6428-0	Acc. 2648		3		5975		20.52		14.56		46.2	
FC (502 x 503) x FC 901	SP 651203H011		4		6080		20.04		15.17		42.8	
(SL 129 x 2648) x SP 6051-0	SP 651213H01		5		5345		18.86		14.17		40.5	
SP 5822-0 (LSR check)	Acc. 2644		6		4571		15.72		14.54		35.7	
US H7 (CTR check)	Acc. 2645		7		5353		18.85		14.20		43.7	
American #2 Monogerm (Local Check)			8		5605		17.90		15.66		39.2	
T22-H7 (Am #3 N Local Check)			9		5432		19.36		14.03		32.7	
General Mean					5598		19.29		14.51		41.3	
LSD (5% Point)					809		2.71		.50		5.2	
F Value					--		3.38**		9.79**		6.53**	
C. V. %					17.6		17.11		4.22		15.44	

Variance Table a/

:		:		:		:	
Source of Variation:		d/f:Roots(lbs.):		Sucrose %:No.Roots(35')		Mean Square (variance)	
Between entries	2	202.065		49.095		106.500	
Replications	9	141.955		4.413		204.777	
Blocks	24	15.331		.592		42.000	
Varieties	8	82.101		3.680		265.375	
Variety x lattice	16	31.478		.487		75.063	
Error	48	24.248		.376		40.625	
Total	107	40.8792		1.938		77.325	

a/ For Gross Sucrose: SE lbs.
sucrose = mean lbs. sucrose x

$$\frac{(\text{SE lbs. beets})^2}{(\text{Mean lbs. beets})} + \frac{(\text{SE\% sucrose})^2}{(\text{Mean \% sucrose})}$$

Table 24(a) .--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Sugar City, Colorado, 1966.

Conducted by: Loyd H. Dillon, National Sugar Manufacturing Company.

Location: Sugar City, Colorado (factory grounds).

Date of Planting: April 28-29, 1966.

Experimental Design: Latin Square, 9 x 9; plots 6 rows x 30'; rows 22" apart; hand thinned to single-plant hills.

Determination of Root Yield: Middle two rows x 30'.

Determination of Sucrose Percentage: All roots harvested for yield determination were analyzed for sucrose content, usually as 3 or 4 samples per plot.

Stand Counts: Harvested roots.

Recent Cropping History: Alfalfa and perennial grass, 1964-65.

Chemicals Applied for Sugarbeet Crop: 150 lbs. of NH_3 and 250 lbs. of 0-52-0 on 3/4 acre.

Leaf Spot Exposure: Trace.

Curly Top Exposure: From trace to 20% in plots of SP 5822-0.

Other Diseases and Pests: Negligible.

Soil and Seasonal Conditions: Irrigated for germination on May 2 and 3, and thereafter as needed.

Reliability of Test: Four plots were deleted at harvest because of poor stand, and the results shown for the 3 varieties concerned should be viewed with caution. Stand was rather poor in several other plots, and may have resulted in appreciable reduction in yield. Two such plots apparently deserve special mention. In one of these--variety 7--the stand (plants per 100 ft.) was 80, and the root yield per acre was 13.66 tons, approximately 5 tons below the variety average. In the other--variety 9--the stand was 75 and the root yield was 12.63, about 4 tons below the variety average. According to the "F" test, the 9 varieties in this test did not differ significantly in root or gross sucrose yield or in sucrose percentage.

Table 24(b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Sugar City, Colorado, 1966 (9-plot averages).

Description	: : : Acre Yield			: : : Stand		
	: Ft. Collins	: Entry:Gross	:	: Roots	: Sucrose	: (beets
	: seed no.	: no. :sucrose :		: Tons	: %	: per 100')
		Lbs.				No.
SL (129 x 133) x SP 6322-0	Acc. 2646	1 5384 ^{a/}		17.46 ^{a/}	15.36 ^{a/}	107 ^{a/}
(SL 126 x SP 6121-0) x SP 6428-0	Acc. 2647	2 5314 ^{b/}		17.26 ^{b/}	15.41 ^{b/}	112 ^{b/}
(SL 129 x SP 6121-0) x SP 6428-0	Acc. 2648	3 5345		17.51	15.23	118
FC (502 x 503) x FC 901	SP 651203H011	4 5476		17.55	15.58	111
(SL 129 x 2648) x SP 6051-0	SP 651213H01	5 5128		16.48	15.56	96
SP 5822-0 (LSR check)	Acc. 2644	6 4867		15.71	15.44	106
US H7 (CTR check)	Acc. 2645	7 5618 ^{a/}		18.64 ^{a/}	15.07 ^{a/}	116 ^{a/}
National blend (Local Ck.)		8 5580		18.08	15.36	102
SL (126 x 128) x SP 5822-0(Local Ck.)		9 5082		16.69	15.16	104
General Mean		5310.38		17.2653	15.3533	107.98
S. E. of var. mean		232.66		0.7203	0.1752	4.52
S. E. of var. mean as % of gen. mean		4.38		4.17	1.14	4.19
L.S.D. (.05)		660		2.04	0.50	13

Variance Table

Mean square (variance)			
Source of variation:D/F:Gross Sucrose: Roots : Sucrose % : Stand :			
Rows	8	2,644,262	11.3270
Columns	8	804,764	8.8583
Varieties	8	544,278	6.8457
Error	52	487,214	4.6694
Total	76		
Calculated F value	1.12	1.47	0.98
			2.45*

* F value exceeds the 5% point.

^{a/} One plot was deleted at harvest because of poor stand. The indicated values are simple, 8-plot averages.

^{b/} Two plots were deleted at harvest because of poor stand. The indicated values are simple, 7-plot averages.

Table 25(a) .--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Kanawha, Iowa, 1966.

Conducted By: American Crystal Sugar Company.

Location: Kanawha, Iowa.

Dates of Planting and Harvest: May 16; October 1.

Experimental Design: 3 x 3 Triple lattice, 9 replications; single-row plots 25 feet long; rows 22" apart.

Determination of Root Yield: Complete plot.

Determination of Sucrose Percentage: Approximately one-half of the beets per plot were bulked as one sample.

Stand Counts: Harvested beets counted when weighed.

Leaf Spot Exposure: Light.

Curly Top Exposure: None.

Other Diseases and Pests: Some Aphanomyces.

Soil and Seasonal Conditions: Soil conditions good. Season was dry during growing period and wet at harvest.

Reliability of Test: Good.

Table 25(b) .--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Kanawha, Iowa, 1966 (9-plot averages).

Description	: Ft. Collins : Entry : Acre Yield : Stand	: seed no. : no. :sucrose: Roots : Sucrose :per 25'	: (Roots	
			Lbs. Tons	% No.
SL (129 x 133) x SP 6322-0	Acc. 2646	1	5217 15.83	16.48 32.2
(SL 126 x SP 6121-0) x SP 6428-0	Acc. 2647	2	5420 16.77	16.16 33.2
(SL 129 x SP 6121-0) x SP 6428-0	Acc. 2648	3	4433 13.45	16.48 29.7
FC (502 x 503) x FC 901	SP 651203H011	4	4354 12.96	16.80 33.1
(SL 129 x 2648) x SP 6051-0	SP 651213H01	5	4363 13.22	16.50 30.8
SP 5822-0 (LSR check)	Acc. 2644	6	4341 13.25	16.38 32.8
US H7 (CTR check)	Acc. 2645	7	4211 12.60	16.71 30.7
T22-H7 (Local Check)		8	4489 13.67	16.42 26.6
American #3 S Monogerm (Local Check)		9	4514 13.72	16.45 30.4
General Mean			4597 13.94	16.49 31.0
LSD (5% Point)			797 2.37	---
F Value			---	3.09** NS
C.V. %			18.35 17.96	3.71 18.88

Variance Table $\frac{a}{\text{variance}}$			
Source of Variation:	d/f:Roots(lbs.):Sucrose %:No.Roots(25')	Mean Square (variance)	
Replications	8	106.561	0.6575 99.625
Component a	12	28.650	0.2066 17.916
Component b	6	51.868	0.5966 21.500
Blocks	15	36.389	0.3366 19.111
Varieties	8	78.208	0.3012 40.500
Error(Intra-block)	46	25.610	0.3886 40.195
Error(Random-block)	64	---	0.3740 34.265
Total	80	41.391	0.3951 41.425

a/ For Gross Sucrose: SE lbs.
sucrose = mean lbs. sucrose x

$$\sqrt{\frac{(\text{SE lbs. beets})^2}{(\text{Mean lbs. beets})} + \frac{(\text{SE \% sucrose})^2}{(\text{Mean \% sucrose})}}$$

Table 26(a) .--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Mason City, Iowa, 1966.

Conducted By: American Crystal Sugar Company.

Location: Mason City, Iowa.

Dates of Planting and Harvest: May 5; October 7.

Experimental Design: Balanced lattice, 9 replications; single row plots, 35 feet long.

Determination of Root Yield: Complete plot.

Determination of Sucrose Percentage: All beets harvested per plot were used for one sucrose sample.

Stand Count: Beets counted at harvest.

Leaf Spot Exposure: Slight.

Curly Top Exposure: None.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: A dry season; good soil conditions.

Reliability of Test: Fair.

Table 26(b) .--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Mason City, Iowa, 1966 (9-plot-averages).

Description	: Ft. Collins : seed no.	: Entry : no.	: Acre Yield		: Leaf ^a / : (Roots : spot : per 35')	Stand	
			: Gross				
			: sucrose:	: sucrose:			
			<u>Lbs.</u>	<u>Tons</u>	<u>%</u>	<u>No.</u>	
SL (129 x 133) x SP 6322-0	Acc. 2646	1	4584	11.64	19.69	2	34.0
(SL 126 x SP 6121-0) x SP 6428-0	Acc. 2647	2	4910	12.82	19.15	1	34.4
(SL 129 x SP 6121-0) x SP 6428-0	Acc. 2648	3	3645	9.21	19.79	2	30.4
FC (502 x 503) x FC 901	SP 651203H011	4	3794	9.47	20.03	1	30.4
(SL 129 x 2648) x SP 6051-0	SP 651213H01	5	4604	11.71	19.66	1	35.2
SP 5822-0 (LSR check)	Acc. 2644	6	3538	8.99	19.68	1	31.0
US H7 (CTR check)	Acc. 2645	7	4816	12.85	18.74	5	41.2
American #3 S Monogerm (Local check)		8	4083	10.29	19.84	3	35.0
General Mean			4261	10.88	19.58		34.0
LSD (5% Point)			868	2.18	.59		6.4
F Value			--	4.42**	3.97**		2.48**
C. V. %			21.57	21.33	3.22		20.01

Variance Table^b/_b

	:	:	Mean Square (variance)	
Source of Variation:d/f: Roots(lbs.):Sucrose %:No.Roots(35')				
Replications	8	48.174	1.014	78.750
Varieties	7	196.663	1.577	114.600
Error	56	46.777	0.397	46.286
Total	71	61.712	0.583	56.676

b/ For Gross Sucrose: SE lbs.
sucrose = mean lbs. sucrose x

$$\frac{(SE \text{ lbs.beets})^2}{(\text{Mean lbs.beets})} + \frac{(SE \% \text{ sucrose})^2}{(\text{Mean \% sucrose})}$$

^a/ Leaf spot readings (D. E. Farus) 0 = no leaf spot; 5 = complete defoliation. (Ratings were made in Leaf Spot Nursery, average of 2 replications, not in field).

Table 27(a) .--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Tribune, Kansas, 1966.

Conducted by: Roy E. Gwin, Jr., G. E. Coupland, and Henry Wolfe.

Location: Tribune Branch Station, Kansas Agricultural Experiment Station, Tribune, Kansas.

Cooperation: Kansas Agricultural Experiment Station and the National Sugar Manufacturing Company.

Date of Planting: May 16 (replanting).

Experimental Design: Randomized block; 9 replications; plots 6 rows x 30'; rows 22" apart; hand thinned.

Determination of Root Yield: 50' of row in each plot.

Determination of Sucrose Percentage: All roots harvested for yield determination were analyzed for sucrose content, usually as 2 or 3 samples per plot.

Stand Counts: Harvested roots.

Preceding Crop: Wheat.

Chemicals Applied for Sugarbeet Crop: 100 lbs. of nitrogen; sprayed twice with Sevin (insecticide).

Leaf Spot Exposure: Trace.

Curly Top Exposure: None.

Other Diseases and Pests: A disease superficially resembling foliar Rhizoctonia was rather common, especially in entry no. 1. Average frequency was estimated to be about 5%; effects, mild.

Reliability of Test: Generally good. Yield in one plot of entry #5 may have been reduced substantially by poor stand. The stand recorded in that plot at harvest was 66 plants per 100', and the root yield in that plot was 12.90 tons per acre, 5 tons below the average for entry #5.

Table 27(b) .--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Tribune, Kansas, 1966 (9-plot averages).

Description	: Ft. Collins : Entry : Acre Yield : Stand	: seed no. : no. : sucrose: Roots : Sucrose : (beets	: 2646 : 1 : 5711 : 19.38 : 14.74 : 128	: 2647 : 2 : 5433 : 17.97 : 15.12 : 131	: 2648 : 3 : 5236 : 17.54 : 14.92 : 138	: SP 651203H011 : 4 : 6020 : 19.65 : 15.33 : 127	: SP 651213H01 : 5 : 5383 : 17.89 : 15.06 : 121	: Acc. 2644 : 6 : 5492 : 18.25 : 15.05 : 118	: Acc. 2645 : 7 : 6516 : 21.98 : 14.82 : 135	: SP 5822-0 (Local Ck.) : 8 : 5780 : 19.30 : 14.97 : 131	: General Mean : 5696.56 : 18.9956 : 15.0014 : 128.58	: S.E. of var. mean : 174.07 : 0.5582 : 0.1821 : 5.1737	: S.E. of var. mean as % of gen. mean : 3.06 : 2.94 : 1.21 : 4.02	: L.S.D. (.05) : 493 : 1.58 : 0.52 : 14.66
SL (129 x 133) x SP 6322-0	Acc. 2646	1	5711	19.38	14.74	128								
(SL 126 x SP 6121-0) x SP 6428-0	Acc. 2647	2	5433	17.97	15.12	131								
(SL 129 x SP 6121-0) x SP 6428-0	Acc. 2648	3	5236	17.54	14.92	138								
FC (502 x 503) x FC 901	SP 651203H011	4	6020	19.65	15.33	127								
(SL 129 x 2648) x SP 6051-0	SP 651213H01	5	5383	17.89	15.06	121								
SP 5822-0 (LSR check)	Acc. 2644	6	5492	18.25	15.05	118								
US H7 (CTR check)	Acc. 2645	7	6516	21.98	14.82	135								
SL (126 x 128) x SP 5822-0 (Local Ck.)		8	5780	19.30	14.97	131								
General Mean			5696.56	18.9956	15.0014	128.58								
S.E. of var. mean			174.07	0.5582	0.1821	5.1737								
S.E. of var. mean as % of gen. mean			3.06	2.94	1.21	4.02								
L.S.D. (.05)			493	1.58	0.52	14.66								

Variance Table

Source of variation	: D/F:	Gross sucrose: Roots	: Sucrose %:	Stand	:
Blocks	8	326,943	2.6402	0.2766	33.7500
Varieties	7	1,549,424	18.6932	0.3046	398.0871
Error	56	272,714	2.8043	0.2984	240.9088
Total	71				
Calculated F value		5.68**	6.67**	1.02	1.65

** F exceeds the 1% point.

Table 28(a) .--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Beltsville, Maryland, 1966.

Conducted by: G. E. Coe.

Location: Beltsville, Maryland.

Dates of Planting and Harvest: May 5; October 11.

Experimental Design: Randomized block, 3 replications; plots 4 rows x 20'; rows 24" apart.

Determination of Root Yield: Middle 2 rows x 20' long.

Determination of Sucrose and Purity Percentages: First 10 roots from each of the two middle rows.

Stand Counts: Harvested beets counted when weighed.

Recent Cropping History: 1961-62, soybeans; 1963-66, sugarbeets.

Chemicals Applied for 1966 Crop: 2 tons limestone per acre in winter of 1965; 450 lbs. 10-6-4 with 2% borax, as side dressing on June 13.

Leaf Spot Exposure: Moderate.

Other Diseases and Pests: Aphanomyces black root exposure, light.

Soil and Seasonal Conditions: Moist seedbed. Below adequate moisture much of growing season. Irrigation applied, but not frequently enough. Flooded the third week in August and wet the rest of the fall.

Reliability of Test: Good.

Table 28(b) .--Results of cooperative agronomic evaluation test of LSP-CTR varieties, Beltsville, Maryland, 1966 (3-plot averages).

Description	: : : : : : : : : : :									
	: Fort Collins:		: Acre Yield :		: : : : : :		: Leaf Spot a/:Plants :		: per :	
	: seed no. :	no. :	no. :	sucrose:	Roots :	Sucrose:	purity:	8/23:8/30:9/8 :	100' :	
					Lbs.	Tons	%	%		
SL (129 x 133) x SP 6322-0	Acc. 2646	1	5288	20.87	12.67	85.5	3.7	4.2	4.1	85
(SL 126 x SP 6121-0) x SP 6428-0	Acc. 2647	2	5246	20.27	12.93	85.9	3.6	4.3	4.5	93
(SL 129 x SP 6121-0) x SP 6428-0	Acc. 2648	3	5024	19.63	12.83	85.4	3.5	4.3	3.8	90
FC (502 x 503) x FC 901	SP 651203H011	4	5022	19.00	13.22	84.4	4.0	4.5	4.5	88
(SL 129 x 2648) x SP 6051-0	SP 651213H01	5	4198	17.03	12.33	83.1	4.0	4.8	4.6	85
SP 5822-0 (LSR check)	Acc. 2644	6	5354	19.62	13.65	86.0	2.7	3.3	3.1	85
US H7 (CTR check)	Acc. 2645	7	3295	16.03	10.32	79.2	5.2	5.5	5.2	83
SP 64194-0 (Local Ck.)		8	5473	21.17	12.95	84.9	2.6	3.2	3.2	88
General Mean			4863	19.2021	12.6125	84.3042				
S.E. of var. mean			199.01	0.9883	.1806	0.3885				
S.E. of var. mean as % of gen. mean			4.09	5.15	1.43	0.46				
L.S.D. (.05)			604	3.00	0.55	1.18				

Variance Table

: :		Mean square (variance)	
Source of variation:D/F:		Gross sucrose:	Roots :Sucrose %:App. purity:
Replications	2	107,618	1.9777 0.5972 1.4850
Varieties	7	1,667,869	9.8431 3.0252 15.1743
Error (remainder)	14	118,822	2.9304 0.0979 0.4529
Total	23		
Calculated F value		14.04**	3.36* 30.90** 33.50**

a/ Leaf spot: 0 = none; 10 = complete defoliation.

* = F exceeds 5% point; ** = F exceeds 1% point.

Table 29(a) .--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Crookston, Minnesota, 1966.

Conducted By: American Crystal Sugar Company.

Location: Crookston, Minnesota.

Dates of Planting and Harvest: May 20; October 7.

Experimental Design: Triple Lattice, repeated three times, 9 replications; single-row plots, 35 feet long; rows 22" apart.

Determination of Root Yield: Complete plot.

Determination of Sucrose Percentage: Approximately one-half of the beets per plot were bulked as one sample.

Stand Counts: Harvested beets counted when weighed.

Leaf Spot Exposure: Light.

Curly Top Exposure: None.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: Good.

Reliability of Test: A very reliable test.

Table 29(b) .--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Crookston, Minnesota, 1966 (9-plot averages).

Description	Ft. Collins seed no.	Entry no.	Acre Yield		Stand {Roots : (Roots : Sucrose : per 35'}
			Gross : sucrose: Roots	% Tons	
			Lbs.	%	No.
SL (129 x 133) x SP 6322-0	Acc. 2646	1	5030	15.15	31.9
(SL 126 x SP 6121-0) x SP 6428-0	Acc. 2647	2	5010	15.00	30.3
(SL 129 x SP 6121-0) x SP 6428-0	Acc. 2648	3	5408	15.09	32.3
FC (502 x 503) x FC 901	SP 651203H011	4	4649	15.92	31.2
(SL 129 x 2648) x SP 6051-0	SP 651213H01	5	4537	16.02	29.3
SP 5822-0 (LSR check)	Acc. 2644	6	4234	14.50	30.8
US H7 (CTR check)	Acc. 2645	7	5327	15.64	32.7
TL4-H11 (Local check)		8	5750	15.66	29.1
American #3 S Monogerm (Local check)		9	5470	15.41	32.3
General Mean			5051	15.38	31.1
LSD (5% Point)			495	.63	2.5
F Value			--	9.98**	4.72**
C. V. %			10.39	4.39	8.60

Variance Table^{a/}

	:	:	Mean Square (variance)	
Source of Variation:d/f:Roots(lbs.):Sucrose %:No.Roots(35')				
Replications	8	15.149	0.9975	8.875
Component (a)	12	16.640	0.3033	3.000
Component (b)	6	41.083	0.4200	3.000
Blocks	18	24.788	0.3422	3.000
Varieties	8	195.869	2.1525	15.625
Error(Intra-block)	46	19.624	0.5002	8.783
Error(Random-block)	64	---	0.4556	7.156
Total	80	37.963	0.6795	8.175

a/ For Gross Sucrose: SE lbs.
sucrose = mean lbs. sucrose x

$$\frac{(SE \text{ lbs.beets})^2}{(\text{Mean lbs.beets})} + \frac{(SE \% \text{ sucrose})^2}{(\text{Mean \% sucrose})}$$

Table 30(a) .--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Artesia, New Mexico, 1966.

Conducted by: W. J. Russell.

Location: Southeastern Branch Station, New Mexico Agricultural Experiment Station, Artesia, New Mexico.

Cooperation: New Mexico Agricultural Experiment Station.

Dates of Planting and Harvest: March 11; September 12.

Experimental Design: Randomized complete block; 4 replications; plots 4 rows x 22' long; rows 20" apart; hand thinned to single plant hills.

Determination of Root Yield: All roots were harvested from the inside 20 feet of the two center rows in each plot. Diseased roots were not weighed for yield. The pulp was frozen and sent to Holly Sugar Corp. for laboratory analysis. Refractometer readings were made prior to freezing the pulp for comparison with laboratory analysis.

Stand Counts: Harvested beets counted when weighed. Diseased roots were counted but not weighed.

Recent Cropping History: Small grains mixed with Hairy Vetch clipping test 1962-65.

Fertilizers Applied for 1966 Crop: Fertilizer was broadcast on March 8 at the rate of 100 pounds Nitrogen and 48 pounds $P_2 O_5$ per acre. A second fertilization was sidedressed on May 2 at the rate of 100 pounds Nitrogen and 48 pounds $P_2 O_5$ per acre.

Leaf Spot Exposure: Severe after September 1.

Curly Top Exposure: Extremely severe.

Other Diseases and Pests: Negligible.

Soil and Seasonal Conditions: The early spring days were cool. Light hail caused minor damage to plants on March 28. Soil was a light clay loam with poor water penetration. All plots were irrigated the day of planting. There was a total of 17 irrigations amounting to 53 acre inches of water. Rainfall amounted to 9.96 acre inches during the growing season.

Remarks: Variability in soil between the north and south halves of the test resulted in a high coefficient of variation. Determination of sucrose percentages was inadvertently omitted in the laboratory.

Table 30(b) .--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Artesia, New Mexico, 1966 (4-plot averages).

Description	Fort Collins	seed no.	no.	Acre yield		Total		Leaf ^{a/}		Curly top ^{b/}		Stand
				: Entry:	: Gross :	: soluble:	: Purity:	: spot	:	:	:	
				: no.	:soluble:	:solids :	:solids :	: 9/12 :	: 7/25 :	: 9/12 :	: foot	
				:solids :	: (refr.):	%	%					No.
				Lbs.	Tons							
SL (129 x 133) x SP 6322-0	Acc. 2646	1	13,400	39.78	16.85	91.9	0.6	1.5	1.8	1.26		
(SL 126 x SP 6121-0) x SP 6428-0	Acc. 2647	2	10,600	30.71	17.25	90.5	3.3	2.0	3.0	1.11		
(SL 129 x SP 6121-0) x SP 6428-0	Acc. 2648	3	11,640	33.00	17.65	89.4	0.8	1.5	2.0	1.24		
FC (502 x 503) x FC 901	SP 651203HO11	4	12,680	35.61	17.80	89.7	0.8	1.0	1.1	1.20		
(SL 129 x 2648) x SP 6051-0	SP 651213HO1	5	12,980	37.82	17.15	92.0	0.4	0.8	0.8	1.34		
SP 5822-0 (LSR check)	Acc. 2644	6	5,000	15.03	16.65	90.0	0.4	7.5	8.8	1.23		
US H7 (CTR check)	Acc. 2645	7	15,200	44.43	17.10	89.7	2.6	0.8	0.9	1.09		
HH-10 [local check (Holly)]		8	11,920	33.65	17.70	90.7	4.0	3.1	4.5	1.37		
42108-07 (Holly)		9	14,120	39.53	17.85	90.7	0.4	2.1	2.1	1.12		
42108-08 (Holly)		10	14,280	41.74	17.10	90.3	0.6	2.1	2.1	1.04		
General mean			12,182	35.13	17.31	90.5	1.4	2.2	2.7	1.20		
(L.S.D. (5% point)			2,570	6.35	n.s.	n.s.	1.3	1.5	1.4	0.24		
(L.S.D. (1% point)			3,470	8.57	n.s.	n.s.	1.7	2.1	1.8	0.32		
Coef. of var. (%)			14.54	12.45	6.56	2.5	63.6	47.0	34.8	13.69		

Analyses of Variance

Source of variation	D/F	Root yield	Total soluble	Purity (%)	Stand
		: Mean sq.:	: solids (%)	: Mean sq.:	: Mean sq.:
Replicates	3	25.45	1.33	1.16	0.90
Entries	9	270.58	14.14**	0.70	0.54
Error	27	19.14	1.29		
Total	39				

a/ Leaf spot: 0 = healthy; 9 = all leaves dead.

b/ Curly top: 0 = healthy; 9 = dead.

* Significant at the 5% level. ** Significant at the 1% level.

Table 31(a) .--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Goodwell, Oklahoma, 1966.

Conducted by: James D. Arnold, H. Eugene Reeves, Bill Ott, Ralph Matlock, and Roy M. Oswalt.

Location: Panhandle Agricultural Experiment Station, Goodwell, Oklahoma.

Cooperation: Oklahoma Agricultural Experiment Station, Holly Sugar Corporation, Great Western Sugar Company, American Crystal Sugar Company, and U.S.D.A. Fort Collins, Colorado.

Dates of Planting and Harvest: March 19; November 9.

Experimental Design: Randomized block; 10 replications; plots 3 rows x 21' (rows 28" apart), center row test variety, 2 rows common border US-35/2; hand trimmed to single-plant hills 9" apart.

Determination of Root Yield: All roots in 16' of harvested row were hand topped, cleaned and weighed.

Determination of Sucrose Percentage: A random sample of 10 roots was taken from the row and taken to Holly Sugar Corporation for analysis.

Recent Cropping History: 1965 forage sorghum.

Chemicals Applied for Sugarbeet Crop: 100 pounds of nitrogen applied March 18.

Leaf Spot Exposure: Severe.

Curly Top Exposure: Moderate.

Other Diseases and Pests: Negligible.

Soil and Seasonal Conditions: The 1966 crop season was unusually dry. However, the months of July and August were above average in precipitation. This temporary wet period aggravated the leaf spot infestation. Adequate soil moisture to prevent severe drought stress was maintained throughout the growing season by means of furrow irrigation. Rainfall from March 1 through October 31 was 12.95 inches.

Table 31(b) .--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Goodwell, Oklahoma, 1966 (10-plot averages).

Description	Fort Collins seed no.	Entry no.	Acre yield		Leaf ^{a/} spot grade
			Gross	Sucrose	
			Lbs.	Tons	
SL (129 x 133) x SP 6322-0	Acc. 2646	1	6341	24.20	1.8
(SL 126 x SP 6121-0) x SP 6428-0	Acc. 2647	2	6024	20.89	1.7
(SL 129 x SP 6121-0) x SP 6428-0	Acc. 2648	3	5694	21.14	1.2
FC (502 x 503) x FC 901	SP 651203H011	4	6567	23.13	1.5
(SL 129 x 2648) x SP 6051-0	SP 651213H01	5	5896	22.62	2.0
SP 5822-0 (LSR check)	Acc. 2644	6	4472	15.84	2.1
US H7 (CTR check)	Acc. 2645	7	5671	23.02	2.9
62-4T33H2 (A. C. S. Co.)		8	6376	25.66	2.7
62-4T32H2 (A. C. S. Co.)		9	7014	28.32	2.1
62-MSH-200 (G. W. S. Co.)		10	7496	27.28	1.2
65-MSH-25 (G. W. S. Co.)		11	6371	23.48	1.8
65-MSH-33 (G. W. S. Co.)		12	6666	25.67	2.3
HH 10 (Local ck.; Holly Sugar Corp.)		13	6275	23.88	2.8
General mean			6220	23.47	2.01
C. V. (%)			14.73	10.50	9.04
L.S.D. (.05)			813	2.19	0.72

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Variance Table

Source of variation	D/F	: Gross sucrose (lbs.)	F	: Roots (tons)	F	: Sucrose %	F
Replications	9	33,609,015.14	40.04**	239.33	39.36**	17.42	12.27**
Treatments (varieties)	12	5,326,242.16	6.35**	99.40	16.35**	5.05	3.56**
Error (remainder)	107 _{b/}	839,302.61				1.42	
Total	128 _{b/}			6.08			
	129						

a/ Basis of leaf spot grades: 0 = healthy; 9 = death due to leaf spot.

b/ Due to calculation of one missing plot (data for sucrose per unit), the error and total degrees of freedom were reduced by one for gross sucrose and sucrose percent.

** F exceeds the 1% point.

Table 32(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Hereford, Texas, 1966.

Conducted by: D. F. Peterson and Paul Scott.

Location: Eddie Reinauer farm, Hereford, Texas.

Cooperation: Holly Sugar Corporation and Eddie Reinauer.

Dates of Planting and Harvest: March 30; November 1.

Experimental Design: Latin Square, 9 x 9; plots 1 row x 54'; rows 30" apart.

Determination of Root Yield: All roots in a 50' section of each plot.

Determination of Sucrose Percentage: Two 15-beet samples per plot.

Recent Cropping History: 1964, onions and carrots; 1965, lettuce and potatoes.

Fertilizer Applied for 1966 Crop: 200# of 21-53-0; 100 units anhydrous ammonia.

Leaf Spot Exposure: Severe (see "Remarks").

Curly Top Exposure: Very severe (see "Remarks").

Other Diseases and Pests: Rhizoctonia root rot caused mild to moderate damage (see "Remarks").

Remarks: Both leaf spot and curly top were very significant factors in this test. Curly top infection occurred early, and susceptible material could not produce a crop of beets. Leaf spot infection occurred in August and continued until harvest. Rhizoctonia also was a factor in this test. It appeared that varieties susceptible to curly top were weakened and made susceptible to Rhizoctonia.

Reliability of Test: It is felt that results from this test are highly reliable and accurately portray what may be expected from these varieties under severe disease conditions.

Table 33 --Cooperative curly top resistance evaluation tests of LSR-CTR varieties, Thatcher and Logan, Utah, 1966.^{a/}

Description	:	:	:	:Thatcher(field) <u>b/</u> :		Logan (greenhouse) <u>c/</u>			
	:	Ft. Collins	:Entry:	C.T. grade		:Plants:		Pre- <u>e/</u> :	C.T. grade
	:	seed no.	: no.	:Actual <u>d/</u> :		: with :		:Actual <u>f/</u> :	% of
	:	:	:	9/1		: inoc.:		:symp.	:US 41
					US 41		symp. period		US 41
						<u>No.</u>	<u>Days</u>		
SL (129 x 133) x SP 6322-0	Acc. 2646	1	7.0	117	20	17	9.6	6.0	125
(SL 126 x SP 6121-0) x SP 6428-0	Acc. 2647	2	7.5	125	20	19	10.8	6.2	129
(SL 129 x SP 6121-0) x SP 6428-0	Acc. 2648	3	8.0	133	20	20	7.6	6.4	133
FC (502 x 503) x FC 901	SP 651203H011	4	7.5	125	20	20	10.6	6.1	127
(SL 129 x 2648) x SP 6051-0	SP 651213H01	5	6.5	108	20	18	12.3	5.5	115
SP 5822-0 (LSR check)	Acc. 2644	6	9.0	150	20	20	8.7	7.8	163
US H7 (CTR check)	Acc. 2645	7	6.0	100	20	18	9.5	4.8	100
Logan 0667					20	18	14.2	3.7	77
US 33			7.5	125	20	18	13.4	5.9	123
US 41			6.0	100	20	19	12.6	4.8	100

^{a/} Tests were conducted at Thatcher and Logan by A. M. Murphy and C. L. Schneider, respectively, U. S. Dept. of Agriculture.

^{b/} Plots 2 rows x 50'; 2 replications; planted during the period, 6/21-24/66; curly top exposure intensified artificially.

^{c/} Seedling technique, with 2 caged leafhoppers per plant; plants in 6" pots with 4 seedlings per pot; 5 replications--i.e. 5 pots for each variety or line.

^{d/} Basis of curly top grades in field plots: 0 = healthy; 9 = death due to curly top.

^{e/} Presymptom period = no. of days from first exposure to leafhoppers until appearance of curly top symptoms.

^{f/} Basis of curly top grades in greenhouse (plants rated individually): 1 = very resistant; 9 = death due to curly top. Symptomless plants were presumed to be escapes and were not included in the computation of curly top grades.



Fig. 3.--Comparison of two sugarbeet varieties under severe leaf spot and very severe curly top exposures, Hereford, Texas, Sept. 22, 1966; 1-row plots:

Left: Entry 6, SP 5822-0
Right: Entry 5, (SL 129 x 2648) MS
x SP 6051-0

(Ft. Collins photo. No. 185-8).

A STUDY OF THE VARIETAL RESPONSE OF
SUGARBEETS TO POSTEMERGENCE HERBICIDES^{1/}

Technical personnel: USDA, E. E. Schweizer (Plant Physiologist, Weed Investigations - Agronomic Crops) and J. O. Gaskill (Research Plant Pathologist, Sugarbeet Investigations)

Numerous investigators have reported that marked differences in tolerance of varieties of a given crop to a herbicide have occurred. Varietal differences to 2,4-D treatment in barley, corn, oats, and soybeans have been reported. We felt that since herbicides are being used widely to control weeds in sugarbeets we should determine the tolerance of several sugarbeet varieties to preplant and post-emergence herbicides. To initiate this research we selected seven sugarbeet hybrids or varieties which had been evaluated by 14 cooperators in 1966 for leaf spot and curly top resistance and for their general agronomic performance. These varieties were selected from what is known as the "Cooperative Evaluation Tests of LSR-CTR Sugarbeet Varieties, 1966".

Our primary objectives were to determine what effect several preplant and postemergence herbicides would have on these varieties. Results from only the postemergence experiment will be reported at this time.

The results from the postemergence experiment are summarized in Tables 1 and 2. The weight of tops was reduced by all postemergence treatments (Table 1). The variety FC (502 x 503) x FC 901 (entry 4) was injured the least by the three postemergence treatments, whereas, the variety GW 674-56C (entry 8) was injured the most. The effect of the herbicide treatments on the mean weight of these 8 varieties is summarized in Table 2. The mean weight of the untreated varieties was 4.75 gm. The mean varietal weight was reduced 25% by 1/2 lb/A of S6173, 84% by 1 lb/A of S6173 and 91% by 4 plus 2.2 lb/A of pyrazon and dalapon. Variety GW 674-56C had a mean weight of 1.78 gm which was significantly lower than the mean weights of the other varieties. The variety FC (502 x 503) x FC 901 had the highest varietal weight (2.6 gm). The effects of 1 lb/A of S6173 and 4 plus 2.2 lb/A of the mixture of pyrazon and dalapon are shown pictorially in Figures 1 and 2 for the varieties, FC (502 x 503) x FC 901 and US H7, respectively.

In summary, the postemergence herbicide treatments reduced the weight of these 8 varieties markedly. The variety GW 674-56C was injured the most, whereas, the variety FC (502 x 503) x FC 901 was injured the least. Additional greenhouse and field research is necessary to confirm these results. We know that sugarbeets are much more susceptible to herbicides under greenhouse conditions than they are under field conditions.

^{1/} See Herbicides Applied and footnote, page 257.

Description of herbicide resistance evaluation test of LSR-CTR sugar-beet varieties under greenhouse conditions, Fort Collins, Colorado, 1966-67.^{1/}

Conducted by: E. E. Schweizer and J. O. Gaskill

Location: Colorado State University, Fort Collins, Colorado.

Cooperation: Colorado Agricultural Experiment Station.

Date of Planting: December 6 (15 seeds per pot). On December 13 thinned to 4 beet seedlings per pot and to 3 on December 20.

Experimental Design: Randomized complete block; 4 replications.

Data Recorded: Number of seedlings emerging initially; injury ratings to sugarbeets on December 9, January 6, and January 21; and top weights on January 21.

Herbicides Applied: Postemergence: S6173 (benzamidooxyacetic acid) at $\frac{1}{2}$ and 1 lb/A and a mixture of pyrazon (5-amino-4-chloro-2-phenyl-3(2H)-pyridazinone) plus dalapon (2,2-dichloropropionic acid) at 4 plus 2.2 lb/A. Herbicides were applied at a volume of 60 gpa broadcast with an endless belt sprayer on December 20.

Stage of Growth at Application: First pair of true leaves 10 to 20 mm long and beets were 50 to 60 mm tall.

Reliability of Test: Generally good. Although many seedlings were killed by the herbicide treatments, there was no evidence of damping off in any of the pots. The untreated beets, variety GW 674-56C, in replication 4 were very distorted and hence this pot was considered as a missing plot since the yield was only 1/4 of that in the other 3 replications.

^{1/} This is a report on the current status of research on weed control practices. It does not contain any weed control recommendations, nor does it imply that the herbicide uses discussed have been registered. All uses of pesticides must be registered by appropriate state and federal agencies before their recommendation.

Table 1.--Response of LSR-CTR sugarbeet varieties to postemergence herbicides in the greenhouse, Fort Collins, Colorado, 1966-67.

Description	Fort Collins seed no.	Entry no.	% Reduction of tops (dry weight)		
			S6173		
			0.5 lb/A:	1 lb/A:	4 + 2.2 lb/A:
SL (129 x 133) x SP 6322-0	Acc. 2646	1	25	88	90
(SL 126 x SP 6121-0) x SP 6428-0	Acc. 2647	2	31	77	81
(SL 129 x SP 6121-0) x SP 6428-0	Acc. 2648	3	19	77	92
FC (502 x 503) x FC 901	SP 651203H011	4	20	74	85
(SL 129 x 2648) x SP 6051-0	SP 651213H01	5	26	90	92
SP 5822-0 (ISR check)	Acc. 2644	6	12	80	90
US H7 (CTR check)	Acc. 2645	7	10	87	99
GW 674-56C (local check)	Acc. 2168	8	52	97	98

Variance Table

Source of variation	D/F	mean square	F value
Replicates	3	0.41	1.24
Treatments	31	14.38	43.58**
Varieties (V)	7	1.21	3.67**
Herbicides (H)	3	142.85	432.88**
V x H	21	0.41	1.24
Error	92	0.33	----
Total	126a/		

a/ Adjusted for one missing pot.

Table 2.--Effect of postemergence herbicides on the dry weight of tops of LSR-CTR sugarbeet varieties in the greenhouse, Fort Collins, Colorado, 1966-67.

Herbicide	Rate lb/A	Entry no. and weight of tops per pot (grams)								Mean
		1	2	3	4	5	6	7	8	
S6173	0.5	3.54	3.41	3.86	3.82	3.67	4.03	4.11	2.24	3.58
S6173	1.0	0.59	1.13	1.11	1.26	0.51	0.94	0.61	0.12	0.78
pyrazon ⁺ dalapon	⁴ 2.2	0.49	0.94	0.39	0.71	0.41	0.45	0.03	0.11	0.44
none	0	4.71	4.96	4.79	4.77	4.98	4.59	4.59	4.64	4.75
Mean		2.33	2.61	2.54	2.64	2.39	2.50	2.33	1.78	

LSD (19:1): Between variety means 0.53; and between herbicide means 0.38.

Interaction - not significant.



Fig. 1.--Effect of 1 lb/A of S6173 and 4 lb/A of pyrazon plus 2.2 lb/A of dalapon on the hybrid FC (502 x 503) x FC 901 (SP 651203H011). Seed planted December 6, seedlings sprayed on December 20, 1966, and photographed on January 21, 1967, (4 replications).



Fig. 2.--Effect of 1 lb/A of S6173 and 4 lb/A of pyrazon plus 2.2 lb/A of dalapon on the variety US H7(Acc. 2645). Seed planted December 6, seedlings sprayed on December 20, 1966, and photographed on January 21, 1967 (4 replications).

RHIZOCTONIA INVESTIGATIONS, FORT COLLINS, COLORADO, 1966^{1/}

(A phase of Beet Sugar Development Foundation Project 25)

John O. Gaskill^{2/}

Results of Rhizoctonia research at Fort Collins in 1965 (2,3)^{3/} were particularly encouraging in indicating that, among the sugarbeet lines evaluated, at least two apparently represented higher levels of resistance than had been achieved in earlier developments. Roots of the two outstanding lines, selected under artificial Rhizoctonia exposure in 1965, were brought to seed in polyethylene enclosures in the greenhouse early in 1966. The two seed lots, representing the respective lines, were designated FC 701 and FC 702. Field evaluation tests on the Hospital Farm at Fort Collins in 1966 centered around these and related lines, and included two methods of disease exposure for one set of material. Twenty three lines or progenies, furnished by the Great Western Sugar Company, also were evaluated. Selection and breeding for Rhizoctonia resistance were continued in 1966.

Experiment R-1

(Comparison of Sugarbeet Lines by Means of Two Inoculation Techniques)

The 8 lines (including commercial varieties) listed in Table 1 were compared in Experiment R-1. Six of them had been used in an experiment in the preceding year, and their descriptions appear in the 1965 report (2). The other two, FC 701 and FC 702, are products of four cycles of mass selection for Rhizoctonia resistance from GW 674-56C and C817, respectively. The former is a commercial Great Western Sugar Company variety. The latter is an increase of "Sel. A54-1 Synthetic",

^{1/} A progress report on investigations conducted by the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, in cooperation with the Colorado Agricultural Experiment Station and the Beet Sugar Development Foundation.

^{2/} Research Plant Pathologist. Assistance of Luther W. Lawson, Agricultural Research Technician, in conducting the field experiments, is acknowledged.

^{3/} Numbers in parentheses refer to Literature Cited.

a product of selection by Dr. LeRoy Powers^{4/} from another commercial, Great Western Sugar Company Variety, GW 359-52R. Rhizoctonia was not a factor in Dr. Powers' selections. Rhizoctonia exposure techniques employed in the root selections leading to the development of the lines listed as entries 902, 903, 905, and 906 are indicated in Table 1.

Experiment R-1 consisted of two 8 x 8 Latin Squares. In one of these (R-1E), the plots were 2 rows (40 inches) wide and 25 feet long. A section, 2 rows x 16 feet, was inoculated by means of the rosette method (1, 4) on July 25, 4 weeks after thinning, using the highly pathogenic Rhizoctonia isolate, B-6. In the other Latin Square (R-1W), plot size was the same, but the portion of each plot considered as inoculated conformed to the dimensions of the area actually inoculated (with isolate B-6) in 1965--i.e. 2 rows x 14 feet. Experiment R-1W was not inoculated in 1966. Both tests were planted on May 25 and hand thinned at about the usual stage of plant development, attempting to leave single-plant hills about 10 to 12 inches apart. Planting rates were adequate to produce satisfactory thinned stands, except as affected by disease in Experiment R-1W. The soil was high in fertility. Irrigation was performed by sprinkler. At harvest (October 11-12), the roots of all living plants in the inoculated portion of each plot were trimmed as mother beets, washed, and weighed.

The results of Experiment R-1E, in which inoculation was performed by the rosette method after the plants had attained considerable size, showed that Rhizoctonia resistance had been improved substantially by selection for resistance in two source varieties or lines (Table 1 and Figure 1). A striking contrast between one of the Rhizoctonia resistant lines (FC 702) and a commercial check variety (US 401) is presented in Figure 2.

In Experiment R-1W, where Rhizoctonia and presumably other disease inocula were relatively abundant in the soil at planting time, much loss of stand occurred before thinning, making it impossible to obtain full thinned stands in many plots. For this reason, it seems advisable to consider actual stand at harvest, as well as percentage survival and root yield, as indications of performance. By all three of these criteria, the results of Experiment R-1W indicated that significant improvement in resistance had occurred as a result of selection in both source varieties (Table 1). That these gains were less impressive than the gains shown by the results of Experiment R-1E, is attributed to several factors. In the first place it is assumed that much of the

^{4/} Formerly Principal Geneticist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Fort Collins, Colorado; deceased.

Table 1.--Comparison of sugarbeet lines for Rhizoctonia resistance, Ft. Collins, Colo., 1966; results presented as ϕ -plot averages (Exp. R-1).

Description and/or source	Sel. for Rhizoc. res.:			Exp. R-LE			Exp. R-1W		
	:	:	:	:	:	:	:	:	:
	: current :			:(Rosette inoc. in 1966):			(Residual inoculum from 1965)		
No. of	: ft. Collins:	Other	Entry:	Harvest results	Actual ¹ /	Harvest results	Actual ¹ /	Harvest results	Actual ¹ /
: cycles :	Method ^a /	:	:	:	Survival ^b /	:	:	:	:
					%	Lbs.	No.	%	Lbs.
						yield ^c /	stand	Survival ^b /	yield ^c /
GW 674-56C	0	---	Acc. 2168	901	23.66	11.55	20.38	3.13	14.55
do.	2	1,1	SP 631001-0	902	41.68*	21.11**	18.13	5.00	30.78*
do.	4	1,23,23,3	SP 661102-0 FC 701	903	73.44**	36.99**	26.00*	10.38**	38.74**
C817 (Sel. A54-1 Syn.)	0	---	SP 621220H0	904	35.39	18.95	18.75	4.13	22.10
do.	2	2,23	SP 621003-0	905	64.83**	33.15**	23.00	9.00*	35.81*
do.	4	2,23,23,3	SP 661103-0 FC 702	906	73.18**	33.11**	27.13**	8.00*	29.26
US 401	0	---	Acc. 2057	907	27.76	15.03	26.88	2.75	10.29
SP 5822-0	0	---	Acc. 2591	908	27.26	13.41	26.25	6.38	23.75
General mean					45.90	22.91	23.31	6.09	25.66
LSD (.05)					13.64	7.02	5.24	3.73	12.81
LSD (.01)					18.24	9.39	7.01	4.98	17.13
Calculated f/					19.71	16.66	4.21	4.65	4.88

a/ Disease (Phizoctonia) exposure techniques used in the respective cycles of root selection: 1--residual inoculum (i.e. inoculum surviving naturally in the field following inoculation of the sugarbeet crop in the preceding year); 2--inoculum applied in a semi-circle, about 1 1/2 inches from the tap root and approximately 1 inch below the soil surface, from 1 to several weeks after thinning of the current crop (i.e. the crop from which the root selections were made); and 3--inoculum applied to the center of the foliage rosette, from 1 to several weeks after thinning of the current crop (so-called "rosette" method).

b/ Percent of thinned stand alive at harvest.

c/ Total weight of roots of living plants per plot (32' of row).

d/ Actual no. of living plants per plot (28' of row).

€/ Total weight of roots of living plants per plot (28' of row).

F_1 — All F values shown are greater than the 1-percent point (3.10).

Average significantly exceeds that of the source variety.

Average exceeds that of the source variety by a highly significant amount--i.e., a difference at least equal to 1SD (.01).

early stand loss in R-1W occurred as a result of residual inoculum of *Pythium* and other damping-off pathogens--organisms to which the respective entries presumably have little if any resistance. Secondly, most of the post-thinning stand losses in Experiment R-1W occurred soon after thinning. Results of earlier experiments had led to the tentative conclusion that the *Rhizoctonia* resistance then available (e.g. in entries such as 902 and 905) was relatively ineffective during the early stages of growth, up to about 2 weeks after thinning. The results of Experiment R-1 tended to support that conclusion. In this connection it should be pointed out that variations in thinned stand in Experiment R-1W could have been due in part to variations in potential seedlings planted per unit of row. Consequently, the thinned-stand averages should be viewed with caution.

Since the most troublesome losses from *Rhizoctonia* in the sugarbeet crop, in general, occur in the middle or latter part of the growing season, the need for improved seedling resistance to *Rhizoctonia* apparently is less urgent than what might be called mid-season or adult-plant resistance.

Experiment R-2

(Evaluation of Single-plant Progenies)

Seed of 36, open-pollinated, single-plant progenies were given preliminary *Rhizoctonia*-resistance evaluation in 1966 in a manner similar to that described for Experiment R-1E. Plots were 1 row (20 inches) wide and 25 feet long. A randomized-block experimental design was used with four replications. The 8 varieties or lines in Experiment R-1 were included in Experiment R-2 as standards.

The relative performance of the 8 so-called standards in Experiment R-2 (Table 2) closely paralleled their performance in Experiment R-1E (Table 1). Although none of the single-plant progenies (seed numbers having suffix numbers other than zero), were substantially higher than FC 701 or FC 702 in percentage survival, many of them equaled or closely approached those lines in that respect, indicating that they merit further evaluation and selection. Of the four open-pollinated lines or varieties in the test, not having a *Rhizoctonia*-resistance selection background, entry no. 919 stood highest in percentage survival. Fourteen of the single-plant progenies exceeded entry 919, in percentage survival, by highly significant amounts. The root yields shown in Table 2, in general, supported the survival percentages. Root yields for some of the single-plant progenies significantly exceeded that of the resistant line, FC 702. However, in the author's opinion, much of the variation among lines, in root yield, was due to differences

Table 2.--Comparison of sugarbeet lines for Rhizoctonia resistance at harvest, Ft. Collins, Colo., 1966; results presented as 4-plot averages (Exp. 3-2).

Description and/or source	Intermediate generations, FC designations, etc.	Current Ft. Collins: Rhizoc. seed no.	No. cycles: res. sel.	Entry no.	Fur-d/Root ^{b/} : Prize ^{c/}		grade
					%	Lbs.	
GW 674-5bC; LSR, MM, com. var.		Acc. 2168	0	911	33.2	9.70	6.3
do.	SP 611107-0	SP 631001-0	2	912	56.4	11.84	7.0
"	" " " " " " " " " " " "	SP 661102-0	4	913	81.0**	17.13*	4.1
"	" " " " " " " " " " " "	SP 651221-4	3	914	67.1**	14.11	3.7
"	" " " " " " " " " " " "	" " -7	3	915	89.18*	19.45*	4.1
"	" " " " " " " " " " " "	" " -9	3	916	52.6	11.00	6.1
"	" " " " " " " " " " " "	" " -10	3	917	59.7*	11.38	7.3
"	" " " " " " " " " " " "	" " -11	3	918	72.1**	17.72*	4.5
C817 ^{d/} ; MM		" 621220H0	0	919	40.6	10.96	1.1
do.	SP 611105-(02)	" 621003-0	2	920	77.9**	18.84*	6.1
"	" " " " " " " " " " " "	" 661103-0	4	921	85.9**	15.43	1.1
"	" " " " " " " " " " " "	" 651221-19	3	922	78.1**	19.68*	4.1
"	" " " " " " " " " " " "	" " -20	3	923	76.0**	18.81*	4.1
"	" " " " " " " " " " " "	" " -28	3	924	82.7**	23.30**	2.1
"	" " " " " " " " " " " "	" " -29	3	925	84.4**	21.30**	4.1
"	" " " " " " " " " " " "	" " -31	3	926	76.2**	16.43	3.1
"	" " " " " " " " " " " "	" " -33	1	927	74.0**	17.93	4.1
"	" " " " " " " " " " " "	" " -36	3	928	68.1*	14.24	4.1
"	" " " " " " " " " " " "	" " -37	3	929	58.6	13.55	1.5
"	" " " " " " " " " " " "	" " -38	3	930	59.7	13.23	1.1
"	" " " " " " " " " " " "	" " -39	3	931	58.9	11.64	6.4
"	" " " " " " " " " " " "	" " -40	4	932	50.1	12.65	1.1
C817 and GW 674-5bC		" " -62	1	933	25.9	5.53	3.1
do.		" " -68	1	934	18.1	4.22	4.1
SP 621160- lines; LSR-BRR, mm		SP 651222-2	1	935	41.4	7.80	7.6
do.		" " -6	1	936	80.6	22.52	3.1
"		" " -10	1	937	44.9	11.73	7.3
"		" " -11	1	938	62.8	15.15	1.1
SP 621220H01 (MM) and other LSR-CTR		" " -30 ^{e/}	1	939	56.9	11.08	7.1
do.		" " -31 ^{e/}	1	940	38.4	5.93	8.5
"		" " -32 ^{e/}	1	941	50.2	13.10	1.1
"		" " -33 ^{e/}	1	942	54.8	14.33	1.1
SP 6051-0 (MM) and other LSR-CTR		" " -35 ^{e/}	1	943	42.0	8.11	1.1
SP 631224-02 (P. mar. bld.) and other LSR-CTR		" " -37	1	944	55.5	15.23	6.1
SP 6373b-01 (M) and other LSR-CTR		" " -38 ^{e/}	1	945	73.7	21.06	4.1
SP 6373b-05 (mm) and " " "		" " -39 ^{e/}	1	946	33.7	6.75	1.1
SP 5831-0; LSR-BRR, mm	SP 611104-0, SP 621004-0	SP 651223-8	3	947	73.4	13.32	4.1
do.	" " " " " " " " " " " "	" " -11	3	948	82.2	24.33	3.1
"	" " " " " " " " " " " "	" " -13	3	949	76.0	18.25	5.1
"	" " " " " " " " " " " "	" " -14	3	950	66.9	18.22	4.1
B. maritima and misc. sugarbeet	" 631150-5	" " -15	2+	951	75.4	16.10	1.1
C817(MM) and misc. incl. B. marit.	" 631150-2	" " -18	3+	952	82.2	20.33	5.0
US 401; LSR-BRR, MM, com. var.		Acc. 2057	0	953	24.9	6.85	8.5
SP 5822-0; LSR-BRR, MM, com. var.		" 2591	0	954	30.3	6.08	8.5
General mean					60.73	14.28	---
LSD (.05)					24.8	7.43	---
LSD (.01)					32.8	9.81	---
Calculated F ^{f/}					4.59	3.78	---

a/ Percent of thinned stand alive at harvest.

b/ Total weight of roots of living plants per plot (16' of row) at harvest.

c/ Visual, pre-harvest estimate of Rhizoctonia injury based on depression of both stand and vigor: 0 = healthy; 10 = complete loss (all plants dead).

d/ C817 is a G.W.S.Co. increase of LeRoy Powers' "Sel. A54-1 Synthetic", a product of selection from GW 359-52R without Rhizoctonia exposure.

e/ Beta maritima may have constituted part of the source of the indicated line.

f/ Each calculated F value exceeds the 1-percent point.

* Average significantly exceeds that of the source variety.

** Average exceeds that of the source variety by a highly significant amount--i.e. a difference at least equal to LSD (.01).

in heterozygosity. FC 702 is considered quite "closely-bred" and less heterozygous than many of the single-plant progenies.

Experiment R-3

(Evaluation of Company Lines)

Experiment R-3 was conducted primarily for the purpose of evaluating the Rhizoctonia resistance of 23 lines or progenies (products of selection under Rhizoctonia exposure) furnished by the Great Western Sugar Company. Experimental design and techniques were the same as for Experiment R-2. Results for the 23 special company lines or progenies will not be reported here. Results for the five lines or varieties, included in the experiment as standards, were as follows (4-plot averages):

Description and/or source	Seed no.	Entry no.	Survival (%)	Rt.yield (Lbs. per 16')	Rhizoc. grade
GW 602 (com'l. var.)	Acc. 2664	961	19.2	4.53	8.8
GW 674-56C (com'l. var.)	Acc. 2168	985	16.1	4.63	8.8
FC 701 (from GW 674-56C)	SP 661102-0	986	74.6**	17.59**	4.5
C817	SP 621220HO	987	27.5	7.63	8.3
FC 702 (from C817)	SP 661103-0	988	72.0**	14.48*	4.8
LSD (.05)			20.2	5.70	---
LSD (.01)			26.7	7.55	---

* Significantly above source variety [difference greater than LSD (.05)].

** Very significantly above source variety [difference greater than LSD (.01)].

The results of Experiment R-3, as shown above, agreed rather closely with those of Experiments R-1E and R-2.

Discussion

The results presented in this report showed conclusively that the average levels of Rhizoctonia resistance occurring in the multigerm populations, GW 674-56C and C817, were raised substantially by several cycles of mass selection under artificial Rhizoctonia exposure. The results also indicated, tentatively, that equivalent levels of resistance can be achieved by selecting in other source material, including certain monogerm lines (e.g. SP 5831-0 and SP 621160- lines).

Although these results are very encouraging, there are several reasons for tempered optimism. In the first place, the stand of resistant lines, such as FC 701 and FC 702, was rather severely damaged by Rhizoctonia in some individual plots inoculated by the rosette method. Furthermore, the tap roots of a substantial proportion of the plants, classed as living in such lines at harvest, were in fact partially if not badly rotted (Figure 1). Some plants classed as living had lost their foliage before harvest, due to crown rot, and then had developed small tufts of new leaves. This tendency, though more pronounced in the susceptible lines (cf. Figure 1), also existed in the resistant lines. The resistance achieved in such lines as FC 701 and FC 702 apparently is relatively ineffective while the plants are small. Finally, the results presented in this report represent response to only one Rhizoctonia isolate and a narrow range of environmental conditions. The need for appraisal of resistance of such lines as FC 701 and 702 under a variety of environmental conditions, including a wide range of biotypes or strains of Rhizoctonia, obviously is urgently needed.

Summary

The Rhizoctonia resistance of eight sugarbeet lines or varieties was compared in the field at Ft. Collins in 1966 by means of two disease exposure techniques (Experiment R-1). One technique involved the placement of Rhizoctonia inoculum in the center of the foliar rosette of the plants 4 weeks after thinning (so-called "rosette" method of inoculation). The other method depended upon residual inoculum in the soil from sugarbeet plants grown and inoculated in the plot area in the preceding year. Separate, 8 x 8 Latin-Square experiments were used for the respective inoculation techniques.

The eight sugarbeet lines or varieties, above, also were compared in another experiment (R-2), together with 36, open-pollinated, single-plant progenies, by means of a randomized-block experiment with four replications. The rosette inoculation method was used. Two of the more resistant lines in Experiments R-1 and R-2 (FC 701 and 702) also were compared with parental and check material in Experiment R-3 which was similar to R-2 in design and techniques.

The results of these experiments led to the following conclusions:

1. The multigerm lines, FC 701 and FC 702, products of four cycles of mass selection for Rhizoctonia resistance, are substantially more resistant to Ft. Collins isolate B-6 of Rhizoctonia than their respective source populations, GW 674-56C and C817, when comparisons are made by means of the rosette method of inoculation under certain conditions.
2. The level of Rhizoctonia resistance in FC 701 and FC 702 is not high enough to prevent severe injury under conditions especially favorable for the development of the disease.
3. The resistance of FC 701 and FC 702 is less effective, if at all effective, when the plants are young.
4. Several sister lines of FC 701 and FC 702 probably are about equal to those two lines in resistance.
5. Lines with resistance equivalent to that of FC 701 and FC 702 probably can be obtained by selecting in populations other than GW 674-56C and C817. Among these populations are certain monogerm lines.

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Fig. 1.--Comparison of sugarbeet lines in resistance to *Rhizoctonia*, Fort Collins, Colorado, 1966. Top--the inoculated portion of four, 2-row plots, indicated by stakes, on October 4; from left to right: (a) FC 702 (derived from C817), (b) GS 674-56C, (c) FC 701 (derived from GW 674-56C), and (d) C817; photo. No. B29-3. Bottom--roots of all living plants in the inoculated area shown at top, as harvested on October 11 (same plot sequence, left to right); badly rotted roots in foreground; photo. No. B29-18.



Fig. 2.--Comparison of sugarbeet lines in resistance to *Rhizoctonia*, Fort Collins, Colorado, October 4, 1966; the inoculated portion of two, 2-row plots indicated by stakes, from left to right: (a) US 401, and (b) FC 702. (Ft. Collins photo. No. B29-12)

COMPARISON OF 3-HYDROXYTYRAMINE AND LEAF SPOT RESISTANCE IN INFECTED
AND NONINFECTED SUGARBEET POPULATIONS

1/

Previous studies by Harrison et al. (3) have shown that 3-hydroxytyramine (1) in beet leaves, when oxidized, is toxic to Cercospora beticola Sacc. grown in pure culture. Harrison et al. (2) also have shown that the production of 3-hydroxytyramine in sugarbeet leaves reaches a maximum as the plant reaches a certain stage of maturity and declines thereafter. They observed an interaction between sampling date and population in the amount of 3-hydroxytyramine present. A study of these data gave an indication that leaf spot susceptible populations reach a maximum and begin to decline in the amount of 3-hydroxytyramine present at an earlier date than do the more resistant populations.

The purpose of this study was to determine the phenological state when 3-hydroxytyramine is maximized, and to establish whether this maximum actually occurs at different stages of maturity for different genetic populations; also to relate, if possible, the differences between the inoculated and noninoculated populations with regard to 3-hydroxytyramine and leaf spot resistance.

Materials and Methods

The experiment consisted of nine populations, planted at both the Colorado State University Agronomy research farm and Mr. J. O. Gaskill's leaf spot nursery, each in four replications, and grown during the summer of 1966. There was practically no leaf spot at the University research farm. The populations were:

- | | |
|---------------------------------------|--|
| 1. US 201 | Highly leaf spot resistant, heterogeneous |
| 2. GWI-29 | Leaf spot resistant, inbred |
| 3. SP 5822-0 | Highly leaf spot resistant, heterogeneous |
| 4. GW 359-52R | Moderately leaf spot resistant,
heterogeneous |
| 5. R & G Pioneer | Leaf spot susceptible, heterogeneous |
| 6. 52-334 | Very leaf spot susceptible, inbred |
| 7. 52-305CMS x 52-407, F ₁ | High 3-hydroxytyramine, homogeneous
hybrid |
| 8. 52-305CMS | Inbred |
| 9. 52-407 | Inbred |

The disease-free planting was made April 11 and harvested October 3. The disease nursery was planted May 3, inoculated July 5, and harvested October 3. Leaf samples were taken five times in the disease-free experiment, from July 7 through August 23. One sampling was made in the disease nursery, July 14. 3-hydroxytyramine was determined in all leaf

1/ Richard J. Hecker, E. Merle Harrison, Grace W. Maag, and Robert W. Pylman.

samples. Leaf spot ratings were made August 25. ^{1/} Root weight and sucrose were determined in both plantings. Pressed juice conductivity was measured in the disease-free planting and thin juice purity was determined from the disease nursery. Actually root weight, sucrose, pressed juice conductivity and thin juice purity, total nitrogen, sodium, and potassium were determined on both plantings but only the above analyses have been completed at time of this report.

Results and Discussion

An analysis of variance of the 3-hydroxytyramine data over all sampling dates from the disease free experiment shows highly significant differences due to populations, dates, and dates x populations (Table 1). The interaction of dates x populations is of interest, indicating that the maximum 3-hydroxytyramine present in beet leaves occurs at different dates for different populations as has been suspected. However, the time of maximum content seems unrelated to leaf spot resistance. Means for all characters in the disease-free experiment are shown in Tables 2 and 3. Means from the disease nursery are shown in Table 4. When comparing 3-hydroxytyramine means in Table 2, GWI-29 (leaf spot resistant) started to drop off in quantity on the second sampling date while SP 5822-0 (highly leaf spot resistant) did not decline until after the fourth sampling date. The remaining populations commenced to decline after the third date. Thus maximum 3-hydroxytyramine and leaf spot resistance do not seem to be associated; resistant populations US 201, GWI-29, and SP 5822-0 maximize on the third, second, and fourth sampling dates, respectively, while R & G Pioneer and 52-334 (leaf spot susceptible populations) maximize on the third date, the same as US 201.

^{1/} Acknowledgement is given Mr. J. O. Gaskill, Research Plant Pathologist, for his cooperation in the experiment and furnishing the leaf spot readings.

Table 1.--Analyses of variance for 3-hydroxytyramine for all dates of sampling from the disease-free nursery and for 3-hydroxytyramine from the July 14 sampling of the disease nursery.

Source of variation	Degrees of freedom	Mean square
<u>Disease-free nursery</u>		
Total	179	
Populations	8	18,081.5972**
Dates	4	4,666.6875**
P x D	32	775.7148**
Replications	3	571.9718
R x P	} (error) 132	286.9500
R x D		
R x P x D		
<u>Disease nursery</u>		
Total	35	
Populations	8	1,643.5075**
Replications	3	200.9000
Residual (R x P)	24	129.6063

Table 2.--3-hydroxytyramine means and standard errors for all populations under disease-free conditions.

Population	Mean and standard error				
	July 7	July 18	July 25	August 8	August 23
US 201	78.12±5.70	105.25± 9.17	106.75± 3.90	84.75±11.05	74.50±7.42
GWI 29	34.25±4.57	89.25±13.30	74.25±16.03	77.00±17.59	67.25±5.50
SP 5822-0	32.75±3.39	58.25±15.48	55.50± 5.66	81.75± 5.13	65.75±6.97
GW 359-52R	51.00±8.96	86.00±10.85	96.75±12.89	93.25± 6.94	83.50±4.25
R & G Pioneer	61.12±8.82	85.25± 5.30	98.50±14.03	86.25± 7.18	65.50±5.56
52-334	11.62±1.03	10.50± 0.79	25.25± 4.94	17.50± 1.85	9.50±1.04
F ₁ hybrid	75.50±7.06	105.62±13.98	100.50± 3.30	135.25±11.71	103.50±7.98
52-305CMS	130.88±4.64	130.00±12.46	135.50± 5.17	107.75±11.04	75.75±2.95
52-407	51.38±2.56	52.88± 6.21	57.75± 5.86	58.75±10.40	43.00±3.89
					52.75±2.84

Table 3.--Weight, sucrose, and conductivity means and standard errors for all populations under disease-free conditions.

Population	Mean and standard error		
	Weight	Sucrose	Conductivity
US 201	5.59±0.50	14.00±0.36	1.025±0.095
GW 29	6.01±0.72	15.12±0.36	0.875±0.063
SP 5822-0	10.85±1.67	15.70±0.41	0.925±0.193
GW 359-52R	13.78±0.74	16.65±0.29	0.875±0.149
R & G Pioneer	9.78±1.46	15.32±0.15	0.950±0.050
52-334	4.66±0.45	15.95±0.29	0.800±0.071
F ₁ hybrid	11.14±0.60	16.22±0.26	0.975±0.025
52-305CMS	4.90±0.32	16.50±0.37	0.825±0.025
52-407	8.69±1.12	15.68±0.33	1.225±0.175

Table 4.--3-hydroxytyramine, sucrose, root weight, leaf spot reading, and thin juice purity means and standard errors from the disease nursery.

Population	Mean and standard error				
	3-hydroxy-tyramine July 14	Sucrose	Root weight	Leaf spot reading	Purity
US 201	50.50± 3.62	14.00±0.26	5.83±0.52	2.00±0.000	95.02±0.76
GW 29	21.12± 1.55	14.68±0.14	8.10±0.39	1.75±0.145	95.38±1.17
SP 5822-0	23.13± 1.66	14.18±0.32	10.30±0.67	2.50±0.288	95.15±0.47
GW 359-52R	37.25± 7.99	14.63±0.14	12.31±1.21	3.25±0.479	93.22±0.79
R & G Pioneer	29.00± 4.41	13.10±0.19	8.90±0.32	4.75±0.250	92.28±2.84
52-334	5.88± 0.43	11.88±0.91	4.29±0.28	6.75±0.250	81.00±0.50
F ₁ hybrid	48.25± 4.40	13.85±0.10	12.73±1.35	3.50±0.289	91.32±0.65
52-305CMS	73.50±12.77	15.10±0.59	6.58±0.55	3.25±0.479	90.98±1.46
52-407	50.13± 5.03	11.43±1.17	7.09±0.28	3.50±0.289	88.75±0.82

There were no significant differences between root weight means for each population at the two locations; however, there were significant differences between populations within locations. Sucrose content was higher in populations in the disease-free nursery, except for US 201, which is to be expected.

Correlations currently completed are shown in Table 5. These correlations are confined within locations, except for leaf spot, these data being available only from the disease nursery. The correlation of greatest interest is 3-hydroxytyramine (under disease-free conditions) vs. leaf spot reading; this is -0.267 but not significant. This same correlation under disease conditions was -0.336*. It should be noted that the 3-hydroxytyramine samples in the disease nursery were taken July 14, while inoculation was done July 5; so the initial infection was just becoming established at this time. These correlations are not high, pointing up again that even though early studies disclosed the relationship between 3-hydroxytyramine content and leaf spot resistance, this relationship does not hold for certain exceptional genotypes. The compound may be necessary for resistance, and the fact that it is toxic to *Cercospora* when oxidized indicates that it is necessary, but perhaps only minimal amounts are needed. The remaining correlations are not different than might be expected.

Table 5.--Correlation coefficients from data obtained from both diseased and disease-free locations.

Character	Character		
	Sucrose	Root weight	Leaf spot reading
3-hydroxytyramine	0.334* ^{1/}	0.073	-0.336*
	-0.047 ^{2/}	0.058	-0.267
Percent sucrose		0.196	-0.573**
		0.428**	-0.069
Root weight			-0.497**
			-0.456**

^{1/} Upper correlation coefficients are for disease nursery

^{2/} Lower correlation coefficients are for disease-free nursery

The correlation of 3-hydroxytyramine quantities in the disease nursery (July 14) and in the disease-free nursery (July 18) was 0.55**. Even though highly significant the relationship of 3-hydroxytyramine at the two locations is certainly not a monotonic function. This is further evidence that environment greatly influences 3-hydroxytyramine content.

A complete analysis of all characters in this experiment will be made and reported in 1967.

Conclusions

Sugarbeet leaves seem to increase in the amount of 3-hydroxytyramine during the active growth and expansion of the leaves. At a certain time, a maximum is reached, followed by a rather rapid decline as the plant and leaves age.

The timing of this maximum occurs at different dates for different genotypes, ranging from mid-July to early August. The time of maximum content of 3-hydroxytyramine seems unrelated to inherent leaf spot resistance.

The correlation of 3-hydroxytyramine content with leaf spot resistance in this experiment is low because of exceptional genotypes such as R & G Pioneer which is susceptible, yet had an average 3-hydroxytyramine content greater than either GWI-29 and SP 5822-0 which are leaf spot resistant.

A complete analysis of these data will be made and reported next year.

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THE PRODUCTION OF 3-HYDROXYTYRAMINE IN GROWTH CHAMBER EXPERIMENTS

Introduction

These exploratory experiments were undertaken in an attempt to delineate the variables affecting the production of 3-hydroxytyramine in sugarbeet leaves. The amount of 3-hydroxytyramine in the leaves of sugarbeets is correlated with resistance of the beets to attacks of Cercospora beticola, Maag et al. (3). However, this correlation is not absolute, and there always has been inexplicable variation within uniform populations when the plants were grown under field conditions. One purpose of this experiment was to measure the variability of 3-hydroxytyramine in plants grown under controlled conditions.

In addition to the positive correlation of 3-hydroxytyramine and leaf spot resistance there always has been a negative correlation between the quantities of 3-hydroxytyramine and its oxidizing enzyme, polyphenoloxidase (2,3). Since copper appears as the central atom in the polyphenoloxidase enzyme molecule, it was included as a variable in this experiment to determine its effect under controlled environmental conditions.

FIRST EXPERIMENT

Materials and Methods

In the first of two experiments two different populations were chosen. One was a completely homozygous annual (produced by Dr. B. Hammond from a haploid) known to be susceptible to leaf spot. The other was an F_1 hybrid (52-305CMS x 52-407, F_1) that produced high levels of 3-hydroxytyramine in the field. This hybrid is considered to be moderately resistant. Seeds were planted February 28, 1966 in eight inch asphalt pots filled with perlite. The plants were transferred from the greenhouse to the growth chamber on April 1.

During the experiment the plants were watered with a modified Hoagland's nutrient solution, one portion of which contained 100 times the normal amount of copper (0.001 moles/liter being normal).

The experiment was a 2 x 2 factorial. There were two populations, two copper levels, three replications, and six plants per replication for a total of 72 plants in the experiment.

The growth chamber was programmed so that lights were on during the periods from 5 AM to 1 PM and 5 PM to 1 AM. The "day" temperatures were 85°F and the "night" temperatures 65°F.

The pots were periodically leached to prevent a salt accumulation. Samples were taken on the dates shown below:

May 9, 1966 - plot basis (1 leaf per plant)

May 24, 1966 - individual plant basis. Average of six leaves taken from each plant.

June 13, 1966 - plot basis (1 leaf per plant)

July 12, 1966 - plot basis (1 leaf per plant)

All plants were inoculated with Cercospora beticola spores June 2, by spraying water suspensions onto the leaves and covering the individual plants with perforated plastic bags. These bags were removed June 6, at which time there was still free water on the leaves. The first leaf spot symptoms appeared June 9, and by June 12 the disease was well advanced. The last leaf samples, July 12, were taken from new growth after the severe epidemic had defoliated the plants. The post inoculation leaves were not infected since the environment was not suited to a continued epidemic.

The plants were harvested July 12 and measured for root weight and sucrose. All the annual plants bolted, except two, starting about May 20.

Results and Discussion

Determinations for 3-hydroxytyramine and the polyphenoloxidase activity were made on each sampling, following methods described by Harrison et al. (1). Polyphenoloxidase activity was determined on a plot basis for the May 9 sampling and on an individual plant basis for the May 24 sampling. 3-hydroxytyramine was determined on an individual plant basis for the May 24 sampling and on a plot basis for the other three samplings. These results are shown in Table 1. The values given for the May 24 sampling are averages of six individual plant determinations. In spite of using genetically homozygous plants in a well controlled environment the differences between replications were large in many cases. In the case of the May 24 individual plant analyses, there were also great differences within replications. It is apparent that despite our efforts to eliminate variability, it persists, little reduced from field studies. The laboratory process has been scrutinized and cannot be charged with all this variability. Hence, the quantity

of 3-hydroxytyramine may be quite labile and subject to micro-environmental differences.

Table 1.--Summary of 3-hydroxytyramine and polyphenoloxidase determinations at various sampling dates.

Sample ^{1/}	Repl- cation	3-hydroxytyramine (mg/100ml extract)				Polyphenoloxidase	
		May 9	May 24	June 13	July 12	May 9	May 24
F ₁ H	1	340.0	771.5	1225.0	594.0	1.16	1.05
	2	330.0	857.5	1210.0	726.0	0.78	1.12
	3	330.0	872.0	1460.0	714.0	1.10	1.03
Average		333.3	833.7	1298.3	678.0	1.01	1.07
F ₁ L	1	350.0	750.5	1225.0	705.0	1.23	1.09
	2	345.0	904.0	1100.0	672.0	1.24	1.06
	3	350.0	758.0	1210.0	816.0	1.23	1.04
Average		348.3	804.2	1178.3	731.0	1.23	1.06
AH	1	221.0	532.0	450.0	420.0	1.15	1.16
	2	280.0	390.0	630.0	303.0	1.14	1.20
	3	277.0	417.5	635.0	378.0	1.17	1.08
Average		259.3	446.5	571.7	367.0	1.15	1.15
AL	1	265.0	445.5	400.0	336.0	1.35	1.20
	2	260.0	421.0	385.0	441.0	1.29	1.15
	3	270.0	442.0	280.0	294.0	1.31	1.08
Average		265.0	436.2	355.0	357.0	1.32	1.14

^{1/} F₁ = 52-305CMS x 52-407, F₁; A = annual.
H = high copper; L = low copper.

The changes in levels of 3-hydroxytyramine during the course of the experiment are shown graphically in Figure 1.

Means and standard errors of individual plant determinations for root weight, sucrose, leaf copper, 3-hydroxytyramine, and polyphenoloxidase are shown in Table 2.

The annual population was higher in mean weight of roots than the F₁ population with no significant difference between low copper and high copper treatments within populations. There was no significant difference between population means or treatment means for percent

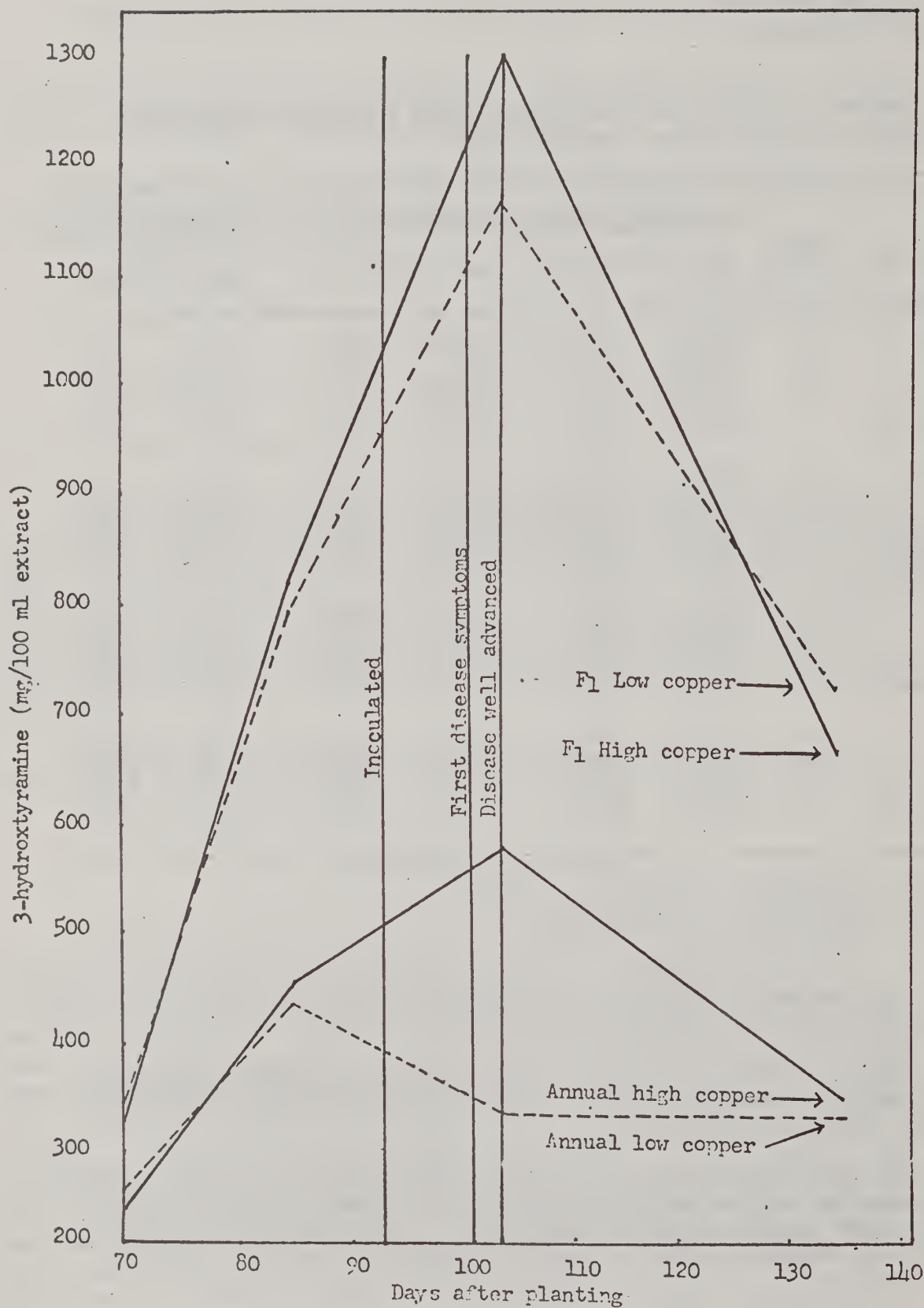


Figure 1.--3-hydroxytyramine determinations at various sampling dates, first experiment.

Table 2.--Means and standard errors for root weight, sucrose, copper, 3-hydroxytyramine, and polyphenoloxidase.

Character and treatment	Population	
	Annual	F ₁
<u>Root weight (grams), July 12</u>		
Low Cu	131.6±6.87	90.0±3.40
High Cu	142.3±7.67	89.1±2.87
Mean	136.9±5.15	89.5±2.20
<u>Sucrose (%), July 12</u>		
Low Cu	12.42±0.186	11.61±0.175
High Cu	12.16±0.163	11.61±0.200
Mean	12.29±0.124	11.61±0.131
<u>3-hydroxytyramine (mg/100ml), May 24</u>		
Low Cu	436±19.7	804±35.4
High Cu	446±21.0	834±24.5
Mean	441±14.2	819±21.4
<u>Polyphenoloxidase (optical density), May 24</u>		
Low Cu	1.14±0.021	1.06±0.017
High Cu	1.15±0.022	1.07±0.019
Mean	1.14±0.015	1.06±0.013
<u>Copper (mg/100ml), May 24</u>		
Low Cu	2.18±0.291	1.88±0.120
High Cu	2.94±0.174	2.43±0.102
Mean	2.56±0.179	2.15±0.090

sucrose. There was a significant difference between populations for amount of 3-hydroxytyramine; however, there was no difference between copper treatments within populations. Polyphenoloxidase was present in equal concentrations in both populations and within both copper treatments. The high copper treatment gave a significantly higher concentration of leaf copper than the low copper treatment. This was true in both populations. The annual population had a higher mean concentration of copper at both treatment levels. Since the F₁ population was higher

in 3-hydroxytyramine than the annual, and had lower concentrations of copper in the leaves, copper does not seem to be the limiting factor in production of 3-hydroxytyramine.

The analyses of variance for 3-hydroxytyramine and polyphenoloxidase are presented in Table 3. There were significant copper treatment effects on the amount of polyphenoloxidase present in leaves on the May 9 sampling. The low treatment plants had higher concentrations of the enzyme (Table 1). Thus, copper was not limiting the quantity of polyphenoloxidase in this experiment. This does not exclude the possibility of a detrimental effect from excess copper.

The May 24 sampling for polyphenoloxidase was analyzed both on a plot basis, using means of individuals within plots, and on an individual plant basis. These analyses show highly significant differences between populations.

The June 13 sampling for 3-hydroxytyramine indicated a significant difference between copper treatments and populations. Plants under the high copper treatment produced more 3-hydroxytyramine. This was most pronounced within the annual population (Table 1). The differentiation of the treatments with respect to quantity of 3-hydroxytyramine commenced prior to inoculation (random occurrence) and continued well after the disease had developed.

Since copper and polyphenoloxidase have been postulated as being involved in formation and/or accumulation of 3-hydroxytyramine, but not limiting factors, some genetically controlled reaction may be affecting the efficiency of 3-hydroxytyramine production.

Table 4 shows the correlation coefficients for the various characters. These correlations were calculated from individual plant measurements. The data for 3-hydroxytyramine, polyphenoloxidase, and copper were obtained from the May 24 sampling, and the data for sucrose and root weight were obtained when the plants were harvested, July 12.

Total and within population correlations are of greatest interest. Since copper treatment had no effect, except in the case of copper content, the two within treatment correlations, in all cases except copper, should be estimates of the same parameter. 3-hydroxytyramine was negatively correlated with polyphenoloxidase, sucrose, and root weight. The negative correlation with polyphenoloxidase is of the same magnitude as in all previous experiments. It seems apparent that the correlation of 3-hydroxytyramine and polyphenoloxidase may be fairly constant in sugarbeets at about -0.5. The negative correlation with root weight has also been common in past experiments. The negative correlation with sucrose is an exception to past experiments, but this is related to the positive correlation of sucrose with root weight. This latter correlation is not unique, particularly for homozygous populations under non-field conditions.

Table 3.--Analyses of variance for polyphenoloxidase and 3-hydroxytyramine; growth chamber experiment number 1, 1966.

Source of variation	Degrees of freedom	Mean square			
		Polyphenoloxidase		3-hydroxytyramine	
		May 9	May 24	May 24	July 12
<u>Plot samples</u>					
Total	11				
Populations	1	0.0374	0.0192**	427,707.513**	1,801,875.000**
Replications	2	0.0138	0.0069*	513.306	6,227.085
Treatments	1	0.1102**	0.0000	1,190.013	85,193.330*
Residual	7	0.0087	0.0010	4,516.275	10,538.453
<u>Individual plant samples</u>					
Total	71				
Populations	1		0.1120**	2,566,245.125**	351,918.75**
Replications	2		0.0405*	3,079.500	1,365.75
Treatments	1		0.0001	7,140.125	1,386.75
P x T	1		0.0000	1,653.125	5,825.04
Residual	66		0.0060	12,353.886	

Table 4.--Simple correlation coefficients (r) in growth chamber experiment number 1.

Character and population-treatment combination ^{1/}	3-hydroxy-tyramine (mg/100ml ext.)	Root weight (gm)	Polyphenol-oxidase (optical density)	Copper (mg/100gm)
<u>Sucrose (%)</u>				
Total	-0.52**	0.33**	0.36**	0.16
F ₁	-0.41*	-0.35*	0.20	0.40*
A	-0.28	0.24	0.25	-0.09
L Cu	-0.55**	0.24	0.32*	0.11
H Cu	-0.49**	0.43**	0.42**	0.38*
F ₁ , L Cu	-0.35	-0.39	-0.14	0.64**
F ₁ , H Cu	-0.52*	-0.32	0.45*	0.31
A, L Cu	-0.27	-0.03	0.34	0.20
A, H Cu	-0.29	0.61**	0.18	0.30
<u>3-hydroxytyramine</u>				
Total		-0.57**	-0.46**	-0.22
F ₁		0.32*	-0.22	-0.15
A		0.07	-0.16	0.06
L Cu		-0.44**	-0.48**	-0.18
H Cu		-0.70**	-0.45**	-0.36*
F ₁ , L Cu		0.48*	-0.29	-0.32
F ₁ , H Cu		0.09	-0.15	-0.12
A, L Cu		0.36	-0.13	0.03
A, H Cu		-0.19	-0.18	0.05
<u>Root weight</u>				
Total			0.18	0.27*
F ₁			-0.22	-0.26
A			-0.22	0.25
L Cu			0.21	0.06
H Cu			0.15	0.54**
F ₁ , L Cu			-0.16	-0.26
F ₁ , H Cu			-0.27	-0.32
A, L Cu			-0.14	-0.03
A, H Cu			-0.30	0.57**
<u>Polyphenoloxidase</u>				
Total				0.02
F ₁				-0.28
A				-0.02
L Cu				0.07
H Cu				-0.06
F ₁ , L Cu				-0.27
F ₁ , H Cu				-0.39
A, L Cu				0.09
A, H Cu				-0.22

^{1/} F₁ = 52-305CMS x 52-407, F₁; A = annual
L Cu = low copper; H Cu = high copper

The within population correlations add little to the information already gained from the total correlations. In certain cases such as root weight with sucrose and with 3-hydroxytyramine, differences due to genotype are reflected in the correlations but they add little new information.

SECOND EXPERIMENT

Materials and Methods

It was shown in the first experiment that available copper, in normal quantities, was not a limiting factor in accumulation of 3-hydroxytyramine or polyphenoloxidase. A second growth chamber experiment was then conducted to determine if leaf spot infection influenced the quantity of 3-hydroxytyramine in the plant. In the first experiment the 3-hydroxytyramine content decreased after the disease was well advanced. However, this decrease could also have been due to age of plant. The object of the second experiment was to determine if the level of 3-hydroxytyramine was conditioned by the presence or absence of infection.

A third variety was added to the annual and the F_1 hybrid of the previous experiment; US 201, a variety known to be very resistant to leaf spot. The light regime was altered to come on at 5 AM and go off at 9 PM with the accompanying temperature at 85°F. The dark period was from 9 PM to 5 AM with the temperature programmed at 65°F. Hence in a 24 hour period there was the same number of hours of light and dark as in experiment 1, but in the first experiment the light was in two portions.

The annual and the F_1 hybrid were planted June 14, and US 201 was planted June 22. All plants were transferred July 13 from the greenhouse to the growth chamber. Samples were taken (1 leaf per plant) on a plot basis on the following dates: August 17, August 26, September 6, September 13, and September 19.

On August 26 half the plants were inoculated with Cercospora beticola spores, as in the first experiment, but much less inoculum was used. The perforated plastic bags were removed August 31.

A summary of the 3-hydroxytyramine determinations are given in Table 5. No determinations were made on polyphenoloxidase activity. The 3-hydroxytyramine data are summarized graphically in Figure 2.

Table 5.--3-hydroxytyramine determinations at various sampling dates with three populations, second experiment.

Population and treatment	Repli- cation	3-hydroxytyramine (mg/100ml extract)				
		Aug. 17	Aug. 26	Sept. 6	Sept. 13	Sept. 19
<hr/>						
<u>Noninoculated</u>						
Annual	1	9.0	172.5	262.5	279.0	417.0
	2	25.5	22.5	46.5	276.0	397.5
	3	10.5	159.0	208.5	405.0	390.0
Average		15.0	118.0	172.5	320.0	401.5
F ₁ hybrid	1	54.0	438.0	241.5	450.0	465.0
	2	103.5	238.5	570.0	472.5	480.0
	3	42.0	123.0	495.0	495.0	495.0
Average		66.5	266.5	435.5	472.5	480.0
US 201	1	18.0	303.0	562.5	408.0	495.0
	2	9.0	165.0	280.5	303.0	352.5
	3	21.0	241.5	510.0	310.5	321.0
Average		16.0	236.5	451.0	340.5	389.5
<hr/>						
<u>Inoculated</u>						
Annual	1	75.0	238.5	489.0	282.0	337.5
	2	22.5	120.0	163.5	387.0	408.0
	3	9.0	105.0	465.0	313.5	472.5
Average		35.5	154.5	372.5	327.5	406.0
F ₁ hybrid	1	97.5	477.0	525.0	480.0	480.0
	2	69.0	480.0	354.0	472.5	487.5
	3	51.0	156.0	480.0	345.0	480.0
Average		72.5	371.0	453.0	432.5	482.5
US 201	1	10.5	390.0	525.0	427.5	465.0
	2	45.0	139.5	487.5	297.0	462.0
	3	46.5	285.0	525.0	435.0	393.0
Average		34.0	271.5	512.5	386.5	440.0

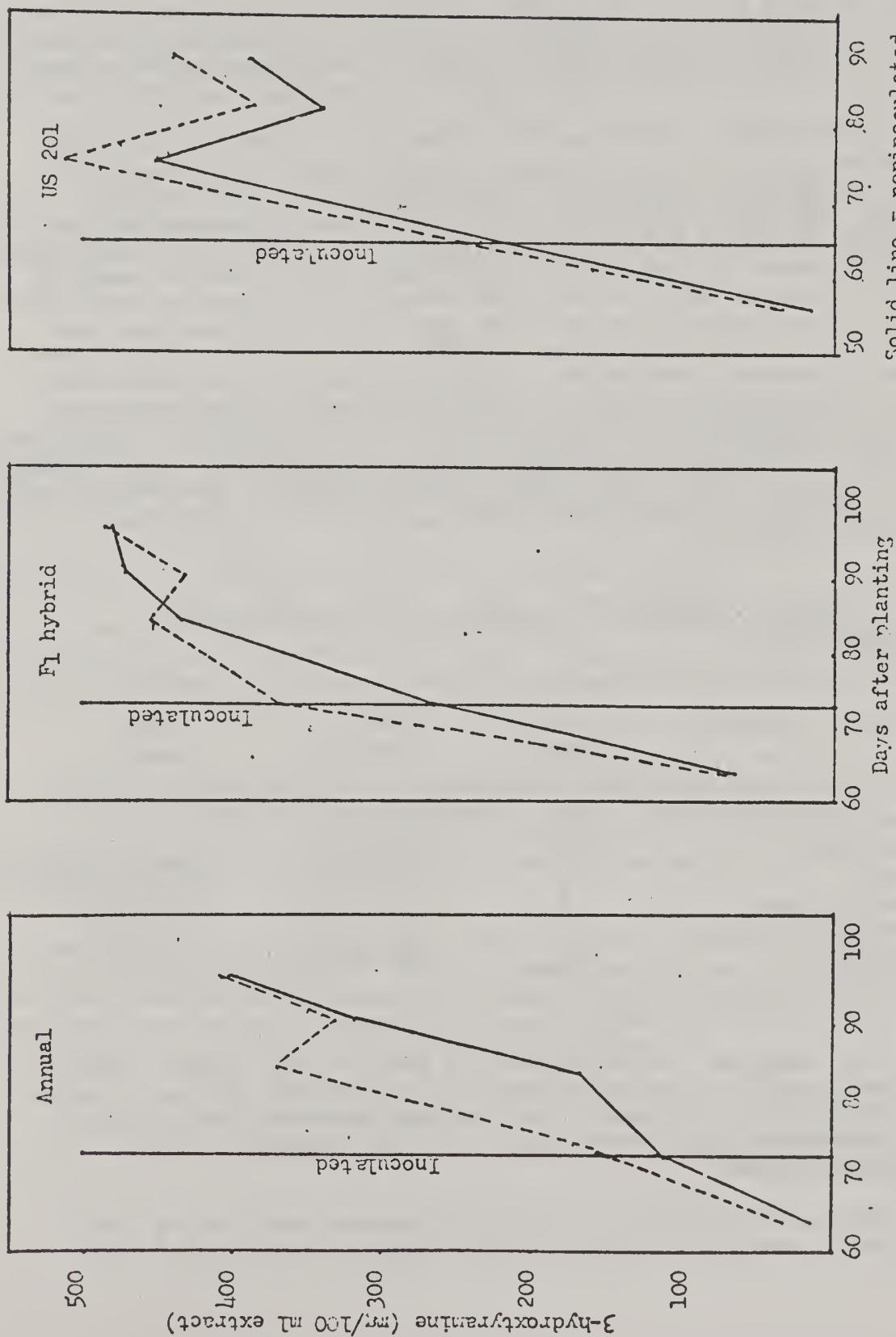


Figure 2.--3-hydroxytyramine determinations at various sampling dates, second experiment.

The age of the plants in each experiment should be kept in mind when comparing the two experiments. In the first experiment the plants were first sampled at 71 days after planting, inoculated at 95 days, and sampled for the last time at 104 days. These same events occurred at 64, 73, and 97 days, respectively, in the second experiment.

Table 6 gives the analysis of variance for the entire experiment. Varieties, replications, and dates of sampling had significant differences in their concentration of 3-hydroxytyramine. The treatment effects and variety by treatment interaction sum of squares were included in the error term since treatments only involved the last three sampling dates. Varieties were ranked consistently from one sampling date to the next, as is shown by the absence of a variety by date interaction. In an analysis of the three post inoculation samplings (not shown), there was no significant treatment effect nor was there a population x treatment interaction. It would appear from this experiment that infection did not induce a significant change in the synthesis and/or accumulation of 3-hydroxytyramine. However there is a consistent increase in the inoculated material and it is our opinion that infection probably does increase the 3-hydroxytyramine content. The increase may be localized on a cellular level, hence, largely undetected by our methods of analysis.

Table 6.—Analysis of variance for the entire second experiment.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	89	2,816,277.85	
Varieties	2	223,873.06	111,936.53**
Dates	4	1,902,885.87	475,721.47**
Replications	2	51,417.05	25,708.53*
Varieties x dates	8	109,183.17	13,647.90
Residual	73	528,918.70	7,245.46

From these and past experiments we now know that disease resistance and quantity of 3-hydroxytyramine are positively related. However the association is not exact, i.e., certain moderately resistant, and even susceptible populations, have relatively high quantities of 3-hydroxytyramine.

The ten-fold increase in 3-hydroxytyramine values in the first experiment, compared to previous field studies, indicate that this

character is conditioned primarily by environment. However in a relatively uniform environment, such as a field study, genotype is the most important determinant. If succeeding studies reveal the full relationship between resistance and 3-hydroxytyramine content, it should be relatively easy to discriminate genetically for this latter character.

A study is being conducted into the inheritance of this quantitative character. Further studies are also being made to determine the major environmental factor or factors conditioning its synthesis and/or accumulation. These include light quality and photo period.

Summary

Two separate experiments were conducted in a controlled environment chamber in an attempt to discover the factors which condition the synthesis and/or accumulation of 3-hydroxytyramine in sugarbeets. The variables in the first experiment were copper level in the nutrient solution, and genotype. There were marked differences in 3-hydroxytyramine due to genotype. All plants contained very high levels of 3-hydroxytyramine compared to earlier field grown materials (up to 10 times) for the same variety and age. High copper levels in the nutrient solution had little effect on 3-hydroxytyramine or its oxidizing enzyme, polyphenoloxidase. Therefore, even though polyphenoloxidase is a copper containing enzyme, it is not affected by a copper level higher than that in the standard Hoagland's nutrient solution.

In the second experiment the variables were genotype, and inoculation with Cercospora beticola. The purpose was to determine if infection induced a change in 3-hydroxytyramine level. Again there were marked differences due to genotype; but inoculation with Cercospora beticola produced no significant differences in the levels of 3-hydroxytyramine.

There was some indication that photoperiod may be a factor in quantity of 3-hydroxytyramine. Earlier greenhouse studies also indicated a possible effect of light quality. These possibilities are being investigated as part of a continuing research effort to discover the fundamental chemical nature of Cercospora resistance.

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ASSOCIATION OF COPPER AND OTHER CHEMICAL CHARACTERS WITH CERCOSPORA LEAF SPOT RESISTANCE IN SUGARBEETS

Introduction

A phenolic compound, 3-hydroxytyramine, identified by Gardner (5), was shown by Harrison et al. (6) to be closely associated in its oxidized form with resistance to Cercospora beticola Sacc. (leaf spot) in culture. Polyphenoloxidase may be the oxidizing enzyme activated by some catalyst. Reports in the literature (11,12) indicate that divalent metallic ions may act as catalysts for this oxidizing reaction in various plants. These studies were conducted in an attempt to link certain cations and other chemicals in the leaf and root tissue to leaf spot resistance and to evaluate the interrelations of various chemicals. Copper was of particular interest since it appears as the central atom in the polyphenoloxidase enzyme molecule.

Materials and Experimental Design

The materials used in this experiment were from the variety A56-3 and self-pollinated lines of A56-3 (S_1 's). This is an open pollinated commercial variety adapted to the east slope of the mountains. Four hundred forty random roots of the A56-3 were self pollinated in 1964. From these, 180 plants produced enough seed under the bags so that they could be planted in two tests as one row plots. Both tests were planted at Fort Collins, Colorado; the one in the leaf spot nursery was planted May 6, 1965; the one grown under disease free conditions was planted April 8. The field design consisted of ten blocks of twenty entries each. In each block, 18 entries were S_1 lines and the remaining two entries were A56-3. Since A56-3 appeared twice in each block, it provided the opportunity to adjust for block differences if these differences were significant. The data were taken on a plot basis from disease free plants. Twelve-root samples were taken from each plot. The usual measurements were made for root weight, sucrose, and thin juice purity. Chloride, sodium, potassium, total nitrogen, and copper determinations were made on thin juice. Dried leaf material prepared from leaves collected and quick frozen August 4 and 5, 1965, was analyzed for copper, calcium, and magnesium. Polyphenoloxidase and 3-hydroxytyramine content were determined on leaf extract from the same leaves.

Leaf spot readings were taken from the duplicate planting made in the leaf spot nursery. The standard leaf spot scoring method from 0 to

10 was used; 0 indicating no infection, and 10 indicating complete defoliation. ^{1/} It was necessary to grow the plants in separate areas so that the characters other than leaf spot resistance could be determined on healthy plants. The relationships of these characters might be altered if they are obtained from diseased plants.

Complete data were obtained on the twenty A56-3 plots and 173 of the selfed lines.

Experimental Methods

The thin juice was prepared from sugarbeet roots by a method developed by Brown and Serro (1) and modified by Carruthers and Oldfield (2). The following characteristics were determined as described by Payne et al. (9,10): percentage sucrose, percent apparent purity, mg of Na, K, and N per 100 ml thin juice. Chlorides were determined in meq/l on the thin juice samples with a chloride titrator (Aminco-Cotlove Automatic Chloride Titrator). The 3-hydroxytyramine and polyphenoloxidase were determined on leaf samples as described by Harrison et al. (7).

The leaf samples were prepared as follows for the determination of calcium, magnesium, and copper on the Perkin-Elmer Atomic Absorption Spectrophotometer 290. Ten grams of center-cut leaves were dried in an oven at about 82°C and ground with mortar and pestle. One half of a gram (measured to four decimal places) was put into a 25 ml digestion tube with five milliliters of a digestion mixture and allowed to stand for 24 hours. The digestion mixture was prepared as follows: Solution I - 10 g. of sodium molybdate and 150 ml H₂O. Solution II - 600 ml of concentrated HNO₃, 200 ml of concentrated H₂SO₄, 150 ml of 70% HClO₄, and 150 ml of Solution I. The tubes were heated on an American Instrument Co. Rotary digestion apparatus for 20 to 30 minutes until the solution was clear. The mixture was cooled, diluted to 25 ml with distilled water and mixed well. This solution was used for determination of Ca, Mg, and Cu. The values reported for calcium concentrations do not reflect the true calcium levels. There were interferences from phosphate and other ions which were not taken into account. However, since the phosphate interference appears to be relatively small and since constant amounts of other reagents were added to each sample, the calcium results are reported and should still give a measure of relative differences in concentrations. In future analyses lanthanum chloride will be added to mask the phosphate interferences and the procedure will be revised to overcome the other

^{1/} The authors are indebted to J. O. Gaskill for leaf spot scores from his leaf spot nursery at Fort Collins, Colorado.

interferences.

Results and Discussion

The arithmetic means and standard deviations for the various chemical determinations for the controls and inbreds combined, are shown in Table 1. The means and standard deviation of the controls were very similar to those of the A56-3 inbreds and were not statistically different; therefore, the study is concerned only with the combined sample of 193 plots. There were no significant block differences.

Tests for normality using the third and fourth moments about the mean were computed for each character measured on the arithmetic, logarithmic, and the square root scales. On the arithmetic scale, weight and purity were found to have a slight positive kurtosis and sucrose a slight negative skewness. None of the transformations attempted improved upon the arithmetic scale for these characters. All of the chemical characters for both thin juice and leaves showed significant positive skewness on the arithmetic scale except for polyphenoloxidase which was significantly negatively skewed. Some degree of positive kurtosis was also noted for most characters. Transformation to the log scale made the distribution of all of the thin juice characters acceptably normal but overcorrected the leaf characters from significant positive skewness to significant negative skewness. The square root transformation was tried for the leaf characters and acceptable normality was achieved except that 3-hydroxytyramine retained a slight positive skewness and magnesium retained positive kurtosis. Polyphenoloxidase presented a special problem as the negative skewness on the arithmetic scale was exaggerated by both the square root and the logarithmic transformations. It was found by trial and error that polyphenoloxidase was normally distributed when transformed to the antilog to the base 10.

Correlation analysis is based on the requirement that a bivariate normal distribution exists. If this is not true, the interpretation of the correlation coefficient is uncertain (3). Changes of scale to achieve approximate normality for each character are essential for a valid study. The changes of scale should also make biological sense and not simply be a mathematical manipulation. Arguments can be presented for the logic of each of the transformations chosen. When the assumption of normality is satisfied, the observed correlation coefficients can be used to test for independence of the two variables involved.

The scales used for correlation analysis as a result of the

Table 1.--Means and standard deviations of A56-3 and A56-3 inbreds.

Character	Mean	Standard deviation
Weight (Kg)	8.012	2.094
Sucrose (%)	14.946	1.192
Thin Juice Purity (%)	91.80	3.702
Leaf spot (score)	4.010	1.535
3-Hydroxy- tyramine (mg/100ml extract)	50.76	31.59
Polyphenoloxidase (optical density after 5 min)	1.186	0.251
Leaf Cu (mg/100ml)	1.394	0.296
Leaf Ca (mg/100gm)	709.870	237.965
Leaf Mg (mg/100gm)	625.492	186.268
Thin Juice Na (mg/100ml)	49.248	24.783
Thin Juice K (mg/100ml)	82.575	18.896
Thin Juice N (mg/100ml)	45.109	17.913
Thin Juice Cu (mg/100ml)	0.212	0.082
Thin Juice Cl (meq/l)	2.128	0.908

normality investigations were: arithmetic scale for weight, sucrose, and purity; antilog base 10 for polyphenoloxidase; square root for the remaining leaf characters; and log base 10 for the thin juice characters. In order to maintain a familiar scale, the means and standard deviations in Table 1 are shown on the arithmetic scale.

It is interesting to note that all of the chemical determinations made were positively skewed on the arithmetic scale with the exception of polyphenoloxidase and that the thin juice characters were log-normal while the leaf characters were square root-normal. This relation could be a result of the physiologic and/or metabolic systems of the plants. Evaluations such as these made on only one population are not sufficient for far reaching conclusion, but it would seem to be a set of relations worthy of further investigation.

The significant simple correlation coefficients of the combined sample of A56-3 and S₁ inbreds are shown in Table 2. There is a small but significant positive correlation between root weight and the thin juice chemical characters sodium, copper, and potassium. No significant relation of weight with the leaf chemical characters exists except for polyphenoloxidase which shows a negative association. Sucrose is negatively correlated with weight and positively correlated with purity as is commonly observed.

The thin juice chemical characters which are generally thought of as impurity components are all negatively correlated with sucrose. These correlations are all of similar magnitude. Purity is also significantly correlated negatively with the thin juice chemical characters but to a lesser degree. Even though these relations are of the same magnitude, sodium, potassium, and total nitrogen contribute much more as impurity components than do chlorides and copper as is shown by the mean quantity of materials present. The thin juice chemical characters are all significantly positively correlated with each other.

The leaf chemical characters are not so highly and consistently correlated. Calcium and magnesium are very highly positively correlated with each other and both positively correlated to the same degree with polyphenoloxidase. Negative association of these two elements are shown with 3-hydroxytyramine to a higher degree than the positive associations with polyphenoloxidase. Polyphenoloxidase and 3-hydroxytyramine are highly negatively related to each other. Leaf copper is negatively associated with polyphenoloxidase. Leaf copper is negatively associated with calcium and positively associated with 3-hydroxytyramine. Only slight associations are indicated between thin juice characters and leaf characters.

Leaf spot readings are negatively associated with 3-hydroxytyramine and leaf copper, and positively associated with magnesium.

Positive relations were also noted between leaf spot and polyphenoloxidase and calcium, but they were not significant.

The general patterns of the relations of leaf spot are consistent with and support the hypothesis that 3-hydroxytyramine oxidized by polyphenoloxidase effects some measure of control on leaf spot. The oxidation process may be catalyzed by calcium and/or magnesium as they are negatively associated with 3-hydroxytyramine, and leaf copper may be used in formation of polyphenoloxidase although the relations are not all significant.

High concentrations of either or both 3-hydroxytyramine and its oxidizing enzyme, polyphenoloxidase, are thought to be necessary for high leaf spot resistance, but it appears that selection for high amounts of both compounds simultaneously would be difficult. One might theorize that the negative correlation between the two may be due to high concentrations of polyphenoloxidase which oxidizes the 3-hydroxytyramine. High concentrations of 3-hydroxytyramine may indicate the lack of enough polyphenoloxidase to oxidize the 3-hydroxytyramine as fast as it is produced. However, this type of mechanism is not the entire answer because a few S_1 lines had high concentrations of both compounds.

The progeny-parent regression coefficients for weight, sucrose, and 3-hydroxytyramine, which are the narrow sense heritability estimates, are shown in Table 3 along with the progeny-parent correlations.

The regression and correlation coefficients were determined from data collected on the S_1 lines in 1965 and from data on the individual parents in 1963. According to Falconer (4), the regression of progeny on mid-parent is a measure of the narrow sense heritability. In the case of self fertilization, the value for the parent is the same as the mid-parent in cross fertilization. Variance due to the additive effects of genes accounted for 57% of the phenotypic variance of 3-hydroxytyramine, 35% in the case of root weight, and 26% in the case of percentage sucrose. The proportion of additive variance in weight has been lower in previous experiments (8), but as is the case for any heritability estimate, conclusions drawn from these data should be applied only to this particular group of S_1 lines.

The parent and progeny measurements for weight, sucrose, and 3-hydroxytyramine were correlated, and it was found that the S_1 lines which had high sucrose had parents that also had high sucrose. The same relationship existed for 3-hydroxytyramine and weight; however, the weight correlation coefficient was not significant. This could be the result of poor stands for some of the S_1 lines which would directly affect root weight.

Table 3.--Progeny-parent correlations and narrow sense heritability ratios estimated from progeny-parent regression.

Character	Correlation coefficient (r)	Heritability h^2
3-Hydroxytyramine	0.2802**	0.57
Percentage sucrose	0.3715**	0.26
Weight	0.1077	0.35

A conservative method of estimating broad sense heritability was used for all characters. Since the data obtained from A56-3, as well as the S_1 lines, were measured on the plot basis and not as individual plants, the A56-3 variance of plot means should have little genetic variance. Therefore, plot measurements on A56-3 can be used to estimate the environmental variance which is subtracted from the total variance for the S_1 lines leaving an estimate of their total genetic variance. This ratio of total genetic variance to total variance estimates broad sense heritability and indicates the expected progress from selection if one is using a breeding method which capitalizes on both additive and nonadditive gene action. These calculations are summarized in Table 4. The broad sense heritability estimates for weight and sucrose are 0.62 and 0.48, respectively. When these estimates are compared with estimates from previous experiments with similar material they appear reasonable (8). Therefore, this method should give a reasonable estimate for chemical characters. The estimate for 3-hydroxytyramine was 0.39 which implies that some progress could be made among these S_1 lines when selecting for high 3-hydroxytyramine provided the proper breeding method was used, but not as much as for weight and sucrose. When the narrow sense heritability estimate from 3-hydroxytyramine shown in Table 3 is compared with the broad sense heritability estimate, it appears that most of the genetic variability is due to additive genes. A larger proportion is indicated than in the case of weight or sucrose. This indicates that mass selection within these S_1 lines should be an effective means for selecting lines having high concentrations of 3-hydroxytyramine. The broad sense heritability coefficients for both leaf spot resistance and polyphenoloxidase were quite high being 0.62 and 0.72. This indicates that genetic shifts could be made in breeding for these characters within this population of S_1 lines, provided all types of gene action were utilized. Narrow sense heritability estimates were not available for these characters. The broad sense

Table 4.--Variances and broad sense heritability estimates of the S₁ lines.

Character	Total variance	Estimated environmental variance	Genetic variance	Heritability ratio (broad sense)
Weight	4.66463	1.78632	2.87831	0.62
Sucrose	1.48726	0.77882	0.70844	0.48
Purity	14.22721	8.71432	5.51289	0.39
Sq. rt. Leaf spot	0.15554	0.05954	0.09600	0.62
<u>Leaf determinations</u>				
Sq. rt. 3-hy-t	4.64815	2.79937	1.84878	0.39
Antilog poly	68.36030	19.07317	49.28713	0.72
Sq. rt. Cu	0.01573	0.01372	0.00201	0.13
Sq. rt. Ca	0.20236	0.24129	---	----
Sq. rt. Mg	0.12760	0.27397	---	----
<u>Thin juice determinations</u>				
Log Na	0.17392	0.05570	0.11822	0.68
Log K	0.05103	0.03445	0.01658	0.32
Log N	0.15257	0.17671	---	----
Log Cu	0.13362	0.15196	---	----
Log Cl	0.17670	0.13730	0.03940	0.22

heritability estimates for purity, sodium, potassium, leaf copper, and chlorides were 0.39, 0.68, 0.32, 0.13, and 0.22. Estimates for the heritability of nitrogen, thin juice copper, calcium, and magnesium were zero, possibly due to the conservative nature of this estimation method.

Conclusions

1. In this study, involving one heterogeneous population and S_1 lines derived from it, the thin juice chemical characters were found to have a log-normal distribution, and the leaf chemical characters were found to have a square root-normal distribution with the exception of polyphenoloxidase which was normal as the antilog to the base 10.

2. Thin juice impurity components (sodium, potassium, total nitrogen, copper, and chlorides) were all positively correlated with each other and negatively correlated with sucrose and purity. However, based on the means, copper and chlorides contribute little to impurity.

3. Leaf chemical characters are not so highly and consistently correlated. The general pattern of the relations is consistent but the correlations are weak. It is possible that any of the divalent ions could catalyze the oxidation of 3-hydroxytyramine by polyphenoloxidase leading to some measure of control of leaf spot; at least the relations do not conflict with this hypothesis. However, this is only theory until more is known of the reactions in the plant.

4. Perhaps the most important information derived from this experiment is that high 3-hydroxytyramine in disease-free plants is associated with high leaf spot resistance.

5. This experiment indicates that a considerable portion of the 3-hydroxytyramine variance is due to additive genes which means that mass selection should be an effective method of selecting for high 3-hydroxytyramine lines. Polyphenoloxidase would very likely respond to the same selection technique.

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RELATION OF 3-HYDROXYTYRAMINE TO WEIGHT PER ROOT AND PERCENT SUCROSE IN SUGAR BEETS

Introduction

The relation of 3-hydroxytyramine content of sugarbeet leaves to weight per root and percentage sucrose was studied experimentally in 1963, 1964, and 1965. The purpose of these experiments was to obtain information about the distribution and variability of 3-hydroxytyramine between and within sugarbeet genotypes and varieties. Such information is needed if 3-hydroxytyramine relations are found to be of direct value in breeding, pathologic, and physiologic studies on improved leaf spot resistance in sugarbeets. Equally important is the relation of 3-hydroxytyramine to yield and quality characters. This is necessary for the simultaneous improvement of all the economic characters.

Literature Review

Interest in the study of 3-hydroxytyramine was generated when Harrison et al. (3), found that a phenolic compound in beet leaves was toxic to leaf spot (*Cercospora beticola* Sacc.) when oxidized in the beet leaf. They also found that the quantity of 3-hydroxytyramine was positively related to leaf spot resistance. This phenolic compound was later identified as 3-hydroxytyramine by Gardner (1). The methods for chemical determination of 3-hydroxytyramine and its oxidizing enzyme, polyphenoloxidase, are described by Harrison et al. (2). The results of a study of the form of the distribution of these two compounds in one population (A56-3) of sugarbeets, as well as other chemical characters, and the mathematical transformations required to obtain normality are described by Maag et al. (5). The distribution and variability of 3-hydroxytyramine in this one population for 1 year was such that the possibility of genetic change by selection appeared very likely. Differences between populations also indicate excellent potential [Harrison et al. (1)] for genetic change. However, the relation to sucrose and yield are not well defined. It is known that 3-hydroxytyramine content is highly variable with extreme differences occurring between and within leaves from the same plant and from different plants of the same variety. These differences are apparently affected by local environmental conditions. A study of this variability and the development of a sampling procedure to obtain consistent estimates of 3-hydroxytyramine content is also reported by Harrison et al. (2).

The distributions of weight per root and sucrose and their inter-relations have been reported by Powers et al. (9), Payne et al. (6), and Powers and Payne (7). Where necessary and informative these relations will be presented here, but major emphasis will be on 3-hydroxytyramine content and its relation to root yield and sucrose content. The analysis will follow the general pattern described by Powers et al. (8).

Materials and Methods

The following populations of sugarbeets were used in the three experiments:

- 1963: A56-3, US 401 (4n), and (52-305CMS x 52-407, F₁).
- 1964: A56-3, SP 5481-0 (2n), SP 5481-0 (4n), and (52-305CMS x 52-408, F₁).
- 1965: A56-3, FC 901, [52-305CMS x (52-430 x 52-407, F₁)] OP, and (52-305CMS x 52-408, F₁).

A56-3, a multigerm open pollinated commercial variety, was used all 3 years. The hybrid (52-305CMS x 52-408, F₁) was used in both 1964 and 1965. Hence eight different populations were used over the 3 years. SP 5481-0 (2n) and (4n) are diploid and tetraploid equivalents of a multigerm open pollinated variety. US 401 (4n) is the tetraploid equivalent of US 401 which is a multigerm open pollinated diploid variety. With respect to leaf spot resistance, US 401 (4n), SP 5481-0 (2n) and (4n), and FC 901 are generally considered to have moderately high resistance. A56-3 is considered to have moderate resistance. Among the four inbred parents involved in the three hybrid populations, 52-305CMS is moderately high in resistance while the other three are quite susceptible. The hybrid (52-305CMS x 52-407, F₁) is moderately resistant; the other two have not been classified for leaf spot resistance.

The experimental materials were grown under irrigation at the Colorado State University Agronomy Research Center, Fort Collins, Colorado, and were planted April 8, April 23, and April 8 in 1963, 1964, and 1965, respectively. The average growing season in Fort Collins is about 145 days. The field design was a randomized block with 40 replicates. In 1963, 10 plants were harvested per plot for a total of 400 plants per population. Twelve plants were harvested from each plot in 1964 and 1965 for a total of 480 observations for each character in each population. The same design was used in all years. However, in 1965, two replicates were deleted from the analysis

because of missing plots for two characters.

Individual plant data were obtained on all populations in all years for weight per root, percentage sucrose, and 3-hydroxytyramine content. Leaf samples for 3-hydroxytyramine were taken in mid-July in 1963 and 1964 and the first week of August in 1965. In 1963 and 1964 the same leaves were used for polyphenoloxidase determinations. Complete analysis for polyphenoloxidase was made only in 1964 and sufficient material was available in only 26 replicates for this determination. Incomplete polyphenoloxidase data were available in 1963.

The data were transformed to scales indicated by Maag et al. (5) and the transformed data were checked for normality and independence of means and variance. Population means and variances were obtained for each year and analyses of variance were computed within and between years for each character. Genetic variances and heritabilities were computed for each character each year using the F_1 variance as an estimate of environmental variance. Correlations within populations using individual plant data were computed for each pair of characters within years and estimates of genetic correlation were obtained. Univariate and bivariate frequency distributions were made and studied for numbers of identifiable genetic deviates.

The univariate frequency distributions were partitioned for all populations for all years using methods of Powers et al. (8). This method adjusts the distributions to eliminate differences between replications within populations and differences between populations, resulting in a common mean for all populations. Using the nonsegregating population as an estimate of the environmental distribution, the distributions of the segregating populations each year were partitioned at approximate points of intersection of the obtained and estimated environmental curves. The identifiable numbers of genetic deviates were differences between obtained and estimated environmental distributions. The same partition points were used in the bivariate distributions for estimation of the identifiable numbers of genetic deviates for combinations of two characters.

Results

The population means and their standard errors for the 3 years of this study are reported in Table 1. The mean weight per root in kilograms and percentage sucrose show year and population differences as expected.

Table 1.--Population means and their standard errors within years.

Population and year	Leaf spot classification	Root weight kgs	Percentage sucrose %	3-hydroxy- tyramine mg/100ml	Polyphenol- oxidase optical density
1963					
A56-3	mr	1.174±0.032	15.38±0.069	6.64±0.242	0.797±0.056
US 401 (4n)	mr	1.127±0.034	14.60±0.080	7.96±0.271	1.015±0.038
52-305CMS x 52-407, F ₁	mr	0.974±0.017	16.15±0.050	17.76±0.265	0.497
1964					
A56-3	mr	0.551±0.012	19.01±0.046	12.14±0.530	1.005±0.015
SP 5481-0 (2n)	r	0.502±0.011	18.76±0.043	8.67±0.390	1.052±0.014
SP 5481-0 (4n)	r	0.572±0.014	18.50±0.056	12.31±0.393	1.009±0.014
52-305CMS x 52-408, F ₁	unk	0.556±0.009	20.03±0.030	23.55±0.550	0.790±0.015
1965					
A56-3	mr	0.689±0.016	15.43±0.060	34.76±1.495	
FC 901	r	0.516±0.013	14.27±0.069	27.85±1.237	
52-305CMS x (52-430 x 52-407, F ₁)	unk	0.417±0.009	15.37±0.048	103.19±2.338	
52-305CMS x 52-408, F ₁	unk	0.566±0.009	15.28±0.033	63.31±1.192	

l/ mr = moderately resistant

r = resistant

unk = unknown resistance

The means for 3-hydroxytyramine show extreme differences between years and between populations. Some of the year effect between 1963 and 1964 was probably due to changes in analytic methods since the determination method was modified in 1964. However, there was undoubtedly a true year effect as there was with weight per root and percentage sucrose, although year effect cannot be isolated from chemical technique for this variable in 1963 and 1964. There was a corresponding change in the standard error for 3-hydroxytyramine from year to year which may be partly due to changes in chemical procedure, but a positive relation between the means and variances appeared to be partly responsible for these year to year differences. The correlations between 3-hydroxytyramine and weight and sucrose should not be affected by this change in chemical procedure, however.

The highest levels of 3-hydroxytyramine each year occurred in the F_1 hybrids. All of these hybrids in this particular study had the same female parent, 52-305CMS. The hybrid (52-305CMS x 52-407, F_1) is rated as moderately resistant to leaf spot as is A56-3, which in 1963 had less than one-half as much 3-hydroxytyramine. In 1964, SP 5481-0 (2n) had the least amount of 3-hydroxytyramine but was classed as being a resistant variety, superior to A56-3 and the F_1 .

The population differences are such that genetic manipulation of the amounts of 3-hydroxytyramine present should be possible. From the population means, it would appear that 3-hydroxytyramine is not closely related to either root weight or percentage sucrose. High levels of all three characters occurred in the hybrid (52-305CMS x 52-408, F_1) in 1964, while in 1963 the highest level of 3-hydroxytyramine occurred with the lowest yielding population, and the lowest level of 3-hydroxytyramine occurred with the highest yielding population.

Complete polyphenoloxidase data (on 26 replications) were available only in 1964 with some partial data in 1963. Fairly large population differences existed for quantity of this enzyme. The lower levels of polyphenoloxidase occurred in those populations which had high levels of 3-hydroxytyramine and vice versa. It is difficult to infer a relation between polyphenoloxidase and weight per root or percentage sucrose from one year with only four populations but as with 3-hydroxytyramine, a close relation probably does not exist.

For variance and correlation analysis each of the characters in each year were transformed to the scale indicated by Maag et al. (5), (weight per root and 3-hydroxytyramine transformed to square roots, sucrose untransformed, polyphenoloxidase transformed to antilog 10). Tests were performed on each set to determine whether or not the transformations were successful in removing any relations between the means and variances which have commonly existed in this type of

data and to determine if the data on the transformed scale are sufficiently normal for valid tests following the analyses of variance.

Tests using the third and fourth moments about the mean were run on each variable, transformed to the scale recommended by Maag et al. (5), for each population in each year to determine whether or not the data were normally distributed. The tests are sensitive with sample sizes such as were used here. It was observed that many variables were significantly non-normal considering variables within years within populations. For example, square root of weight per root was significantly negatively skewed in three cases, significantly positively skewed in one case, and acceptably normal in seven cases; sucrose, which was handled on the arithmetic scale as has been the usual practice, was found to be significantly negatively skewed in eight cases, significantly positively skewed in two cases, and acceptably normal only once. Obviously, no transformation can possibly produce overall normality when one population is highly negatively skewed and another highly positively skewed in the same year. The chosen transformations are superior to no transformations and allow an acceptable analysis.

The relation between the means and variances for each variable for each population in each year was also studied. The same lack of pattern was found with some significant positive relations, some significant negative relations, and some nonsignificant relations. It is impossible to remove the relation between means and variances in all cases with a uniform transformation. The mean-variance relation for the F_1 's used as a measure of environmental variability has been removed or decreased in most cases, however.

Analyses of variance were performed on the transformed data for each character for each year and reported in Table 2. The population and replication effects were significant for nearly all characters in all years; however the magnitude of these differences is such that the population effect is of greatest concern. The population by replication interaction was significant in six of the ten cases. Environmental differences, as indicated by the replication effects and the replication x population interactions, are minor as compared to the population effects.

Combined analyses of variance were computed to evaluate the year effects and the population x year interactions (Table 3). A56-3 was used in all years and A56-3 and (52-305CMS x 52-408, F_1) were common to 1964 and 1965. These tests are based on only one degree of freedom and broad generalizations should not be made without further study. However, the anticipated year effect is significant

Table 2.--Analyses of variance for weight per root (kgs), percentage sucrose, 3-hydroxytyramine (mg/100ml), and polyphenoloxidase (optical density), (transformations as noted), for three years.

Year and source of variation	Degrees of freedom	Mean square			
		$\sqrt{\text{Root weight}}$	Sucrose	$\sqrt{3\text{-hydroxytyramine}}$	Antilog $\frac{1}{\text{polyphenol-oxidase}}$
1963					
Populations	2	0.5317**	240.1743**	360.2464**	
Replications	39	0.0732	24.5461**	9.0966**	
P x R	78	0.0633	6.0961**	2.0861**	
Residual	1080	0.0780	1.8333	0.6972	
1964					
Populations	3	0.2161**	213.7442**	317.4579**	1686.3915**
Replications	39	0.0400**	12.6754**	32.8003**	679.2404**
P x R	117	0.0194	3.8082**	4.0648**	86.0740**
Residual	1760	0.0310	0.9648	1.5617	38.9127
1965					
Populations	3	2.5526**	136.8993**	2384.8758**	
Replications	37	0.0503*	33.7621**	37.0614**	
P x R	111	0.0288	4.5814**	12.2164**	
Residual	1672	0.0299	1.3317	4.9647	

$\frac{1}{\text{polyphenoloxidase}}$ Degrees of freedom are 3, 25, 75, and 1112, respectively, for each source of variation for polyphenoloxidase.

Table 3.--Analyses of variance for weight per root (kgs), percentage sucrose, and 3-hydroxytyramine (transformations as noted), three years (1963, 1964, 1965) combined.

Source of variation	Degrees of freedom	Mean square		
		$\sqrt{\text{Root weight}}$	Sucrose	$\sqrt{3\text{-hydroxytyramine}}$
Years	2	38.3445**	8843.1000**	7690.8741**
Populations within years	8	1.1712**	191.5349**	1103.4368**
Replications within years	115	0.0546	23.4855**	26.1326**
P x R within years	306	0.0340	4.6719**	6.5173**
Residual	4512	0.0418	1.3086	2.6158
A56-3 only				
Between years	2	11.8058	2002.4538	1064.4171
A56-3 and (52-305CMS x 52-408,F ₁)				
Years	1	0.9493	8104.2380	3443.7843
Populations	1	0.2953	93.3355	1641.6128
Y x P	1	0.6564	158.2373	98.0632

for all characters (when considering A56-3 only). The year by population interaction is significant for all characters but is usually much smaller in magnitude than either the year or population effects. A study of the means (Table 1) indicates that this interaction exists but also indicates that if a population has a high yield, sucrose content, or 3-hydroxytyramine content in any year, that population will probably be relatively high in all years. The interaction stems from the fact that the population differences vary within years even though the general ranking is the same.

The correlations within populations and within years for each pair of characters are shown in Table 4. These correlations were calculated from individual plant determinations and include both the genetic and environmental correlation. None of the correlations are large but many are significant. The correlation between sucrose and weight is negative in most cases as is generally expected.

Weight and 3-hydroxytyramine are positively related in all populations and years in this study. This relation is not large but is significantly greater than zero in most cases, indicating genetic linkage, epistasis, and/or interallelic interaction.

The relation between sucrose and 3-hydroxytyramine is somewhat erratic. Significant correlations exist in all years and both significant positive and negative relations exist in 1965. These correlations are not as high nor as consistent as those between weight and 3-hydroxytyramine. Simultaneous selection for high sucrose and high 3-hydroxytyramine will probably present the same problems as selection for high sucrose and high root yield.

A significant negative relation exists between 3-hydroxytyramine and polyphenoloxidase. The correlations of polyphenoloxidase with weight per root are negative but not significant, while the correlations with sucrose are positive, with two being significant. This pattern is consistent with the preceding discussion as well as with those previously reported by Maag et al. (5).

The genetic correlations are presented in Table 5. These correlation coefficients were calculated from estimates of the genetic variances and covariances, which in turn were estimated as differences between the respective variances and covariances of the segregating and nonsegregating populations. These genetic correlations should represent the genotypic relationship of the various characters. In testing these genetic correlations for significance the degrees of freedom for the genetic variances and covariances, and thus the

Table 4.--Simple correlation coefficients (r) within populations and years.

Year and character combination	Population			
	A56-3	US 401 (4n)	52-305CMS x 52-407, F ₁	
1963				
<u>√Root weight vs. sucrose</u>	-0.131**	0.093	-0.391**	
<u>√Root weight vs. √3-hydroxytyramine</u>	0.147**	0.156**	0.280**	
<u>Sucrose vs. √3-hydroxytyramine</u>	0.197**	0.204**	0.100*	
<u>3-hydroxytyramine vs. polyphenoloxidase</u>	-0.537**			
1964				
	A56-3	SP 5481-0 (2n)	SP 5481-0 (4n)	52-305CMS x 52-408, F ₁
<u>√Root weight vs. sucrose</u>	-0.175**	-0.053	-0.007	-0.412**
<u>√Root weight vs. √3-hydroxytyramine</u>	0.059	0.180**	0.117**	0.239**
<u>√Root weight vs. antilog polyphenoloxidase</u>	-0.037	-0.046	-0.100	-0.030
<u>Sucrose vs. √3-hydroxytyramine</u>	0.047	0.030	0.076	-0.130**
<u>Sucrose vs. antilog polyphenoloxidase</u>	0.037	0.196**	0.048	0.154**
<u>√3-hydroxytyramine vs. antilog polyphenoloxidase</u>	-0.406**	-0.283**	-0.209**	-0.330**
1965				
	A56-3	FC 901	52-305CMS x (52-430x52-407, F ₁)	52-305CMS x 52-408, F ₁
<u>√Root weight vs. sucrose</u>	-0.115*	0.116*	-0.056	0.008
<u>√Root weight vs. √3-hydroxytyramine</u>	0.163**	0.070	0.063	0.044
<u>Sucrose vs. √3-hydroxytyramine</u>	-0.012	0.139**	-0.119**	-0.080

Table 5.--Genetic correlations within populations and years.

Year and character combination	Degrees of freedom (for testing r)	Population		
		A56-3	US 401 (4n)	SP 5481-0 (4n)
1963				
<u>Root weight vs. sucrose</u>	178	0.122	0.419**	
<u>Root weight vs. $\sqrt{3}$-hydroxytyramine</u>	178	0.038	0.011	
Sucrose vs. $\sqrt{3}$ -hydroxytyramine	178	0.420**	0.336**	
1964				
<u>Root weight vs. sucrose</u>	218	-0.059	0.363**	0.279**
<u>Root weight vs. $\sqrt{3}$-hydroxytyramine</u>	218	-0.902**		
<u>Root weight vs. antilog polyphenoloxidase</u>	143	-0.008	-0.074	-0.203*
Sucrose vs. $\sqrt{3}$ -hydroxytyramine	218	0.100		
Sucrose vs. antilog polyphenoloxidase	143	-0.031	0.156	-0.204*
1965				
<u>Root weight vs. sucrose</u>	226	-0.140*	0.198**	52-305CMS x (52-430x52-407, F ₁) -0.022
<u>Root weight vs. $\sqrt{3}$-hydroxytyramine</u>	226	0.210**	-0.047	-0.065
Sucrose vs. $\sqrt{3}$ -hydroxytyramine	226	0.093	0.216**	-0.129

genetic correlations, were obtained from the theoretical form of the variance of the estimates of genetic variances and covariances. Degrees of freedom is generally considered as the divisor in the equation for a variance. In this case if σ_g^2 (or cov_g) = 0, the degrees of freedom is one-half that of the total within plot correlation. Even a sizeable value for σ_g^2 will change this value only slightly; hence the degrees of freedom used for testing the genetic correlations were considered as a good approximation of the true degrees of freedom. From the 3 year study it is apparent from the correlations of root weight with 3-hydroxytyramine for A56-3 that a year by genotype interaction is present and has considerable effect. The difference between populations is marked, indicating that the genes conditioning each character must be different in the different populations. In other words each of these characters seems to be conditioned by several genes.

The total genetic variance was computed for each population for each year based on the total within plot variance of each population and using the total within plot variance of the nonsegregating F_1 as an estimate of the environmental variance. Broad sense heritability ratio estimates were computed for each population for which an estimate of genetic variance could be obtained and are presented in Table 6.

The heritability ratios for root weight and sucrose are quite consistent and little affected by years. However the heritability ratios for 3-hydroxytyramine are affected by years. Therefore the variability in quantity of 3-hydroxytyramine is affected by the environment and by genotype, which tends to detract from the value of the heritability ratios. It appears that little can be accomplished by a comprehensive study of the variability of 3-hydroxytyramine until its environmental influences are more clearly defined.

The estimates of identifiable numbers of superior and inferior genetic deviates are also included in Table 6. These estimates are expected numbers of genetically inferior and superior individuals in each population for each character and as such provide an empirical comparison of the relative breeding value of each segregating population. These expected numbers of genetic deviates in the case of 3-hydroxytyramine are of dubious value since the population variance can be greatly influenced by unknown environmental factors. One thing worthy of note and further study is that the estimate of superior genetic deviates is usually less than the estimate of inferior ones (classing high 3-hydroxytyramine as superior). Identifiable numbers of genetic deviates should serve as comparative breeding values in the case of root weight and sucrose percentage.

The association between the expected number of genetic deviates

Table 6.--Heritability ratios (h^2) and identifiable numbers of superior and inferior genetic deviates, expressed as percent of the total population.

Year and population	<u>√Weight per root</u>			Percentage sucrose			<u>√3-hydroxytyramine</u>			Antilog polyphenoloxidase		
	h^2	Number of deviates		h^2	Number of deviates		h^2	Number of deviates		h^2	Number of deviates	
		Sup.	Inf.		Sup.	Inf.		Sup.	Inf.		Sup.	Inf.
1963												
A56-3	0.623	13.2	14.5	0.484	7.5	8.5	0.342	8.2	13.0			
US 401 (4n)	0.689	14.5	16.8	0.615	11.2	8.0	0.355	6.5	10.2			
1964												
A56-3	0.403	5.8	7.3	0.582	9.2	8.5	0.048	1.5	6.9	0.421	7.0	9.3
SP 5481-0 (2n)	0.418	8.1	7.5	0.530	9.6	8.1		2.1	7.7	0.452	9.3	11.9
SP 5481-0 (4n)	0.579	9.6	11.7	0.725	12.7	11.5		1.2	3.8	0.374	7.7	11.9
1965												
A56-3	0.643	13.4	13.2	0.689	16.2	11.0	0.483	7.9	11.2			
FC 901	0.595	9.9	11.2	0.767	18.6	13.4	0.479	8.1	11.8			
52-305CMS x (52-430x52-407, F ₁)	0.343	6.8	5.7	0.508	9.6	9.2	0.650	19.7	13.2			

(in percent of the total) and heritability can be determined by their correlation. This correlation, if high, would indicate that the populations were normally distributed, since Hecker (4) states that under conditions of normality the proportion of genetic deviates should be a monotonic (increasing) function of heritability and, hence, an equivalent index. These correlations were calculated. For 3-hydroxytyramine the coefficients were 0.88 and 0.85, respectively, for heritability with the number of superior and inferior genetic deviates. These same correlations are also relatively high for root weight and percentage sucrose: 0.92, 0.97, and 0.90, 0.86. In this experiment the heritability ratios and identifiable numbers of genetic deviates provide equivalent information except that the identifiable numbers of genetic deviates allow one to see whether or not high and low deviates contribute equally to the genetic variability of the population.

The partitioned bivariate distributions provide the identifiable numbers of genetic deviates for combinations of two characters in Table 7. These are average numbers of individuals superior or inferior for two characters simultaneously. These values are a function of the correlation of two characters and their heritabilities but they provide information not readily observable by studying the correlations and heritability ratios. For instance it is apparent from Table 6 that there are no individuals superior or inferior for both 3-hydroxytyramine and polyphenoloxidase. This was not readily observable by studying the correlation coefficients and the heritability ratios. It would apparently be futile to select for high 3-hydroxytyramine and high polyphenoloxidase in the three populations studied in 1964. Genetic deviates superior for 3-hydroxytyramine and weight or sucrose occur with about equal frequency in all populations. However the frequency is not very high indicating some difficulty in selecting for these combinations. Genetic deviates superior for both weight and sucrose occur more frequently than any other combination of characters but there is considerable difference between populations and possibly some difference between years.

Discussion

It is apparent from the means and partitioned univariate frequency distributions that there is considerable variability in quantity of 3-hydroxytyramine due to genotype. According to Maag et al. (5) a larger proportion of this variability may be due to additive gene effects than to root weight and sucrose percentage. So it should be possible to shift the quantity of 3-hydroxytyramine by selection or choice of parents in a hybrid combination provided the considerable environmental effect on 3-hydroxytyramine can be separated from the

Table 7.--Heritability ratios (h^2) for the respective characters (in order) and identifiable numbers of genetic deviates, expressed as percent of the total population, in sections 4, 5, and 6 (superior), and in sections 1, 2, and 8 (inferior) for the bivariate frequency distributions.

Year, character, and population	Heritability ratio		Identifiable numbers of genetic deviates	
	h^2	h^2	Sup. %	Inf. %
<u>1963</u>				
<u>√Weight vs. sucrose (n=400)</u>				
A56-3	0.623	0.484	9.0	11.0
US 401 (4n)	0.689	0.615	8.5	8.5
<u>√Weight vs. √3-hydroxytyramine (n=400)</u>				
A56-3	0.623	0.342	10.0	9.5
US 401 (4n)	0.689	0.355	8.8	8.8
<u>√3-hydroxytyramine vs. sucrose (n=400)</u>				
A56-3	0.342	0.484	8.0	9.0
US 401 (4n)	0.355	0.615	9.8	2.5
<u>1964</u>				
<u>√Weight vs. sucrose (n=480)</u>				
A56-3	0.403	0.582	10.6	8.3
SP 5481-0 (2n)	0.418	0.530	13.5	9.4
SP 5481-0 (4n)	0.579	0.725	8.8	10.8
<u>√Weight vs. √3-hydroxytyramine (n=480)</u>				
A56-3	0.403	0.048	3.3	9.6
SP 5481-0 (2n)	0.418		4.6	9.8
SP 5481-0 (4n)	0.579		5.4	7.7
<u>√3-hydroxytyramine vs. sucrose (n=480)</u>				
A56-3	0.048	0.582	7.9	9.4
SP 5481-0 (2n)		0.530	7.5	6.0
SP 5481-0 (4n)		0.725	6.2	4.0
<u>√Weight vs. antilog polyphenoloxidase (n=312)</u>				
A56-3	0.403	0.421	-1.3	5.8
SP 5481-0 (2n)	0.418	0.452	5.4	7.4
SP 5481-0 (4n)	0.579	0.374	4.5	9.3
<u>Sucrose vs. antilog polyphenoloxidase (n=312)</u>				
A56-3	0.582	0.421	5.1	5.8
SP 5481-0 (2n)	0.530	0.452	11.2	10.6
SP 5481-0 (4n)	0.725	0.374	10.3	11.5
<u>√3-hydroxytyramine vs. antilog polyphenoloxidase (n=312)</u>				
A56-3	0.048	0.421	-3.5	-1.0
SP 5481-0 (2n)		0.452	-4.8	2.6
SP 5481-0 (4n)		0.374	-5.1	4.5
<u>1965</u>				
<u>√Weight vs. sucrose (n=456)</u>				
A56-3	0.643	0.689	17.1	9.6
FC 901	0.595	0.767	21.3	16.9
52-305CMS x (52-430 x 52-407, F_1)	0.343	0.508	11.0	7.9
<u>√Weight vs. √3-hydroxytyramine (n=456)</u>				
A56-3	0.643	0.483	12.3	11.6
FC 901	0.595	0.479	6.1	11.4
52-305CMS x (52-430 x 52-407, F_1)	0.343	0.650	15.1	11.2
<u>√3-hydroxytyramine vs. sucrose (n=456)</u>				
A56-3	0.483	0.689	12.1	7.2
FC 901	0.479	0.767	11.4	4.2
52-305CMS x (52-430 x 52-407, F_1)	0.650	0.508	13.2	6.6

genetic effect. Further studies are currently under way in an attempt to determine the environmental factors influencing 3-hydroxytyramine. Some difficulty might be experienced in advancing both root yield and quantity of 3-hydroxytyramine, as well as sucrose content and 3-hydroxytyramine. From those populations grown in 1964 it appears virtually impossible to increase quantities of 3-hydroxytyramine and polyphenoloxidase simultaneously. Since certain of these 1964 populations were quite heterogeneous this relationship might be expected to extend extensively through the species.

Even though positive associations between quantity of 3-hydroxytyramine and leaf spot resistance have been established, Harrison et al. (3), and Maag et al. (5), it is apparent from the data of this experiment and Harrison et al. (2), that there are exceptions to this relationship. It is not a one-to-one association. It would appear that quantity of 3-hydroxytyramine cannot be used directly as a measure of leaf spot resistance. Further studies are being conducted to determine the exact relationship of these two characters and the relationship of leaf spot resistance with related phenolic compounds and their related enzymes. A direct quantitative determination of some compound as a precise measure of leaf spot resistance would be extremely valuable, but considering the number of alternative pathways that exist for most metabolic processes it would appear unlikely that any single chemical determination could serve as a direct and precise measure of leaf spot resistance. However a combination of two or more determinations or their ratio might ultimately be a more precise and economic measure of leaf spot resistance than actual plant observations under leaf spot conditions.

Summary

It is known that 3-hydroxytyramine found in sugarbeet leaves is toxic, when oxidized, to Cercospora beticola in pure culture. The oxidizing enzyme polyphenoloxidase is also known to be in beet leaves. The distribution and variability of 3-hydroxytyramine and its oxidizing enzyme between and within varieties was studied to determine the quantity and relationships of this phenolic compound with root yield and sucrose content. Information was also obtained on the relation of 3-hydroxytyramine to the improvement of leaf spot resistance in sugarbeets.

The study was conducted over 3 years and included eight different varieties and hybrids. Population differences in quantity of 3-hydroxytyramine and polyphenoloxidase were of sufficient magnitude to indicate

that genetic manipulation is possible. Differences due to environment, years, and replications, were also significant. Even though the variety by year interaction was significant the general ranking of their means was the same over years.

Total correlations between 3-hydroxytyramine and weight per root were small but positive and generally significant. Correlations of 3-hydroxytyramine and sucrose percentage were positive and negative but low. Polyphenoloxidase and 3-hydroxytyramine were consistently negatively correlated and relatively high. The polyphenoloxidase correlations with weight and sucrose were small and generally not significant.

Genetic correlations indicate an effect of environment on genetic expression and that different genes are active in all populations for all characters.

Broad sense heritability ratios were quite consistent for weight per root and sucrose content over years and populations, ranging from 0.403 to 0.689 and 0.484 to 0.767, respectively. Heritability of 3-hydroxytyramine was affected considerably by unaccountable environmental variability and ranged from 0 to 0.650.

Identifiable numbers of genetic deviates for both univariate and bivariate frequency distributions were estimated. If one considers these numbers to be expected breeding values, they correspond very closely to the heritability estimates. They have the advantage of showing whether or not high and low deviates contribute equally to the genetic variability of the population. They also indicate the potential for simultaneous increase of any two characters. There were superior and inferior genetic deviates for all combinations of characters except 3-hydroxytyramine and polyphenoloxidase.

It appears that quantity of 3-hydroxytyramine cannot be used as a direct measure of leaf spot resistance even though there is a general relationship between them.

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P A R T V

Progress reports of research conducted at
Michigan State University, East Lansing, Michigan
and
Plant Industry Station, Beltsville, Maryland
by the
Staff of Sugarbeet Investigations, ARS-USDA
in cooperation with:

Michigan Agricultural Experiment Station
Beet Sugar Development Foundation
Farmers & Manufacturers Beet Sugar Assoc.

Research was conducted by:

G. J. Hogaboam	F. W. Snyder
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G. E. Coe	

EVALUATION OF SUGARBEET VARIETIES AND BASIC BREEDING MATERIAL
SUITABLE FOR THE GREAT LAKES REGION

1/

The evaluation program was continued in 1966 on a cooperative basis as it has been for several years. Stands were better this year than in the past. Tests with poor stands are not included in the report. The report is divided into two sections: 1) Agronomic Evaluation which contained five hybrids and SP5822-0 in 6 x 6 latin square designs; 2) Area Evaluation tests composed of two basic groups of hybrids within which females could be compared across males and vice versa. The area evaluation test also included two hybrids, SL(129x133)ms pollinated by SP5822-0 and by SP6428-01, which were each entered under two different entry numbers to enable more precision in cross comparisons between the two basic groups of hybrids. Three other hybrids and SP5822-0 were added to complete the 36 x 6 design.

Section One: Agronomic Evaluation

Summary of the 1966 Agronomic Evaluation Tests (pages 325 and 326) reveals that three hybrids (Entries 1, 2, and 3) were significantly above other entries in tons of roots and in pounds of recoverable sugar per acre, and for these characteristics, there was no significant difference among these superior hybrids. When these three hybrids were examined for clear juice purity, however, (SP6121 x EL31)ms X SP5822-0 was found to be significantly below both SL(129x133)ms X SP5822-0 and SL(129x133)ms X SP6322-0. Unfortunately, of these hybrids, the one with significantly more resistance to leaf spot is lowest in purity.

It was possible to make female comparisons between (SP6121 x EL31) and SL(129x133) across a common pollinator for the years 1964, 1965, and 1966. These data indicate that (SP6121 x EL31)ms is lower in purity but much higher in leaf spot resistance than SL(129x133)ms. The yield of roots and recoverable sugar per acre and percent sucrose are not strikingly different.

The 1965 and 1966 data were examined for differences between SP5822-0 and SP6322-0 as pollinators of SL(129 x 133)ms. When the data are combined, significant differences are lacking but slightly in favor of SP6322-0.

1/ Compiled by G. J. Hogaboam and cooperators.

AGRONOMIC EVALUATION

TABLE OF PERFORMANCES IN PERCENT OF THE GENERAL MEAN OF THE TEST

Entry → Test ↓	1#	2	3	4	5	6	LSD _{5%}	General Mean
<u>Lbs. Recoverable Sugar per Acre^a</u>								
Miller	101.9	106.5	99.9	102.5	97.8	91.3	7.6	4,967
Gremel	111.5	110.4	102.0	95.0	94.6	86.5	12.9	4,939
Groulx	103.1	99.5	111.9	100.1	96.4	89.0	NS	4,030
Helmreich	109.3	103.6	96.8	99.1	97.4	93.8	NS	6,222
C&D Farm	108.3	95.7	110.0	98.6	100.8	86.6	NS	4,583
W.O.A.S.	101.5	108.3	108.8	92.3	98.3	90.8	--	7,647
AVERAGE	105.9	104.0	104.9	97.9	97.6	89.7	5.7 [@]	5,398

<u>Tons of Roots per Acre</u>								
Miller	102.5	106.7	100.8	99.0	98.4	92.5	5.3	16.87
Gremel	109.7	111.9	104.8	93.9	93.3	86.2	11.5	18.32
Groulx	103.3	102.6	109.6	100.2	94.8	89.4	NS	12.87
Helmreich	105.4	106.4	99.0	97.6	96.2	95.3	NS	21.72
C&D Farm	110.9	99.2	104.5	95.7	99.2	90.4	NS	20.47
W.O.A.S.	100.1	106.4	108.9	95.6	97.9	91.2	11.1 [@]	27.08
AVERAGE	105.3	105.5	104.6	97.0	96.6	90.8	4.6 [@]	19.56

<u>Recoverable Sugar per Ton^a</u>								
Miller	99.8	99.8	98.7	103.8	99.4	98.4	NS	294.7
Gremel	101.5	98.9	97.4	101.1	101.1	100.0	NS	270.0
Groulx	99.8	97.2	102.0	99.8	102.0	99.1	NS	312.7
Helmreich	103.7	97.4	97.7	101.6	101.2	98.4	NS	286.5
C&D Farm	98.0	97.1	106.0	102.4	100.7	95.8	NS	225.5
W.O.A.S.	101.6	101.8	99.8	96.7	100.6	99.4	NS [@]	282.18
AVERAGE	100.7	98.7	100.3	100.9	100.8	98.5	NS [@]	279.05

#	Entry No.	Seed Number
1		SL(129x133)ms X SP5822-0
2		(SP6121xEL31)ms X SP5822-0
3		SL(129x133)ms X SP6322-0
4		(SL129xSP6121)ms X SP6428-0
5		(SL126xSP6121)ms X SP6428-0
6		SP5822-0

@ Calculated from an analysis of % performance of entries vs. tests.

Standard Footnote a. on page 328.

AGRONOMIC EVALUATION

TABLE OF PERFORMANCES IN PERCENT OF THE GENERAL MEAN OF THE TEST

Entry → Test ↓ a	1#	2	3	4	5	6	LSD 5%	General Mean
<u>%Sucrose</u>								
Miller	100.0	100.3	98.7	102.7	99.4	99.0	NS	16.14
Gremel	101.9	100.6	97.0	99.7	100.8	100.1	NS	15.71
Groulx	99.9	97.7	101.4	99.3	101.6	100.2	NS	17.42
Helmreich	102.7	99.0	97.8	99.8	101.5	99.1	NS	16.30
C&D Farm	97.4	98.2	104.9	102.1	100.7	96.4	NS	13.50
W.O.A.S.	101.1	101.9	99.6	98.7	99.9	98.7	NS [@]	15.99
AVERAGE	100.5	99.6	99.9	100.4	100.7	98.9	NS [@]	15.84

<u>% Clear Juice Purity</u> ^a								
Miller	99.9	99.8	100.0	100.6	100.0	99.7	NS	95.07
Gremel	99.8	99.2	100.2	100.6	100.2	100.0	0.8	92.32
Groulx	99.9	99.8	100.3	100.3	100.3	99.5	NS	94.30
Helmreich	100.4	99.2	100.0	100.9	99.8	99.7	1.0	93.32
C&D Farm	100.3	99.6	100.3	100.2	100.0	99.7	NS	91.05
W.O.A.S.	100.3	99.9	100.1	99.1	100.3	100.3	NS [@]	94.28
AVERAGE	100.1	99.6	100.2	100.3	100.1	99.8	0.5 [@]	93.39

<u>Beets per 100'</u>								
Miller	102.9	103.8	103.8	99.3	96.5	93.8	6.4	109.8
Gremel	102.1	106.2	107.2	97.9	91.8	94.8	8.2	97.0
Groulx	100.8	101.8	103.7	97.8	97.8	97.8	NS	102.2
Helmreich	103.8	104.7	100.0	96.2	96.2	99.1	NS	106.0
C&D Farm	112.8	87.6	105.7	103.7	98.7	91.6	14.2	99.3
W.O.A.S.	-----	-----	-----	-----	-----	-----	-----	-----
AVERAGE	104.5	100.8	104.1	99.0	96.2	95.4	5.7 [@]	102.86

Leaf Spot (Actual data instead of % of General Mean) ^b

C&D Farm	5.5	4.2	5.2	4.7	4.2	3.0	.5	4.4
----------	-----	-----	-----	-----	-----	-----	----	-----

# Entry No.	Seed Number
1	SL(129x133)ms X SP5822-0
2	(SP6121xEL31)ms X SP5822-0
3	SL(129x133)ms X SP6322-0
4	(SL129xSP6121)ms X SP6428-0
5	(SL126xSP6121)ms X SP6428-0
6	SP5822-0

@ Calculated from an analysis of % performance of entries vs. tests, Standard Footnotes a., and b. on page 328.

AGRONOMIC EVALUATION TEST

Conducted by: John Niederer

Location: Henry Miller - Marlette, Michigan

Cooperation: F&M Beet Sugar Assoc. - Michigan Sugar Company

Date of Planting: May 5, 1966

Date of Harvest: October 17, 1966

Experimental Design: 6 x 6 Latin Square

Size of Plots: 4 rows x 28' long x 30" between rows.

Harvested Area per Plot for Root Yield: 4 rows 28' long.

Samples for Sucrose Determination: 10 beet sample taken prior to harvest from each plot, 10 beets were taken consecutively in a row where they were growing competitively.

Stand Counts: Harvested beets counted when weighed.

Recent Field History: 1964 - Beets - 600# 6-24-12 plus 50# N sidedress.
1965 - Corn - 400# 6-24-12 broadcast plus 75# N.

Fertilization of Beet Crop: 600# 6-24-12 plus 50# N sidedress

Black Root Exposure: None

Leaf Spot Exposure: None

Other Diseases and Pests: None

Soil and Seasonal Conditions: Wet at planting time and dry during growing season.

Reliability of Test: Good

Cooperator: F&M Beet Sugar Association - Michigan Sugar Co. Year 1966

Location: Henry Miller Farm Marlette, Michigan Exp. 1002

6 X 6 Latin Square

Variety	Recov. Sugar per A. ^a Lbs.	Roots per Acre Tons	Sugar per Ton ^a Lbs.	Sucrose ^a %	Purity ^a %	Beets per 100' No.	Leaf ^b Spot Rating
SL(129x133)msXSP5822-0	5061	17.3	294	16.14	94.97	113	
(SP6121xEL31)msXSP5822-0	5288	18.0	294	16.19	94.87	114	
SL(129x133)msXSP6322-0	4962	17.0	291	15.93	95.06	114	
(SL129xSP6121)msXSP6428-0	5093	16.7	306	16.58	95.61	109	
(SL126xSP6121)msXSP6428-0	4860	16.6	293	16.04	95.10	106	
SP5822-0	4536	15.6	290	15.98	94.80	103	
General Mean	4967	16.9	294	16.14	95.07	110	
S.E. Var. Mean	127.6	0.2941	5.78	0.2678	0.2283	2.29	
Above as % Gen. Mean	2.57	1.74	1.96	1.66	0.24	2.09	
LSD 5% Point	376	0.9	N.S.	N.S.	N.S.	7	

Latin Square Analysis			Variance Table				
			Mean Squares				
Source of Variation:	D/F:					Beets:	
		Recov.:	Sugar :			per :	Leaf
		Sugar :	Roots:per T.:	Sucrose:	Purity:	100':	Spot
Between Rows	: 5 :	239,060:	2.41:	316	:0.6661	:0.3441:	73 :
Between Columns	: 5 :	323,058:	2.59:	97	:0.1679	:0.6821:	36 :
Between Varieties	: 5 :	389,559:	3.65:	197	:0.3256	:0.5044:	135 :
Remainder (Error)	:20 :	97,742:	0.52:	200	:0.4305	:0.3129:	32 :
Total	:35 :						
Calculated F.Value	: 3.99*	: 7.03:	N.S. :	N.S. :	N.S.:	4.22:	

Standard Footnotes:

a. Data obtained according to procedures as given by Dexter, S. T., M. G. Frakes, and F. W. Snyder, A Rapid and Practical Method of Determining Extractable White Sugar as may be Applied to the Evaluation of Agronomic Practices and Grower Deliveries in the Sugar Beet Industry, Journ. Amer. Soc. of Sugar Beet Technol. 14: 433-454. 1967.

b. Rating scale: 0 = no evidence of disease; 10 = complete necrosis due to leaf spot.

AGRONOMIC EVALUATION TEST

Conducted by: John Niederer

Location: Harold Gremel - Sebewaing, Michigan

Cooperation: F&M Beet Sugar Assoc. - Michigan Sugar Company

Date of Planting: April 16, 1966

Date of Harvest: October 27, 1966

Experimental Design: 6 x 6 Latin Square

Size of Plots: 4 rows x 28' long x 28" between rows.

Harvested Area per Plot for Root Yield: 4 rows x 28" long.

Samples for Sucrose Determination: One 10 beet sample taken prior to harvest from each plot. 10 beets were taken consecutively in a row where they were growing competitively.

Stand Counts: Harvested beets counted when weighed.

Recent Field History: 1964 - Corn - 300# 4-16-4 ZN.
1965 - Beans - 250# 8-32-16 plus MN plus ZN.

Fertilization of Beet Crop: 550# 8-32-16 plus B plus MN

Black Root Exposure: Slight

Leaf Spot Exposure: None

Other Diseases and Pests: None

Soil and Seasonal Conditions: Moist at planting time - less than normal rainfall during growing season.

Reliability of Test: Good

Cooperator: F&M Beet Sugar Association - Mich. Sugar Co. Year 1966

Location: Harold Gremel Farm, Sebewaing, Michigan Exp. 1003

6 X 6 Latin Square

Variety	Recov. sugar per A. ^a Lbs.	Roots per Acre Tons	Sugar per Ton ^a Lbs.	Sucrose ^a %	Purity ^a %	Beets per 100' No.	Leaf Spot ^b Rating
SL(129x133)msXSP5822-0	5509	20.1	274	16.01	92.11	99	
(SP6121xEL31)msXSP5822-0	5452	20.5	267	15.80	91.56	103	
SL(129x133)msXSP6322-0	5040	19.2	263	15.24	92.52	104	
(SL129xSP6121)msXSP6428-0	4691	17.2	273	15.67	92.92	95	
(SL126xSP6121)msXSP6428-0	4674	17.1	273	15.83	92.47	89	
SP5822-0	4270	15.8	270	15.72	92.34	92	
General Mean	4939	18.3	270	15.71	92.32	97	
S.E. Var. Mean	216	0.71	4.95	.2494	.2478	2.83	
Above as % Gen. Mean	4.37	3.87	1.83	1.59	0.27	2.92	
LSD 5% Point	637	2.1	N.S.	N.S.	0.73	8	

Latin Square Analysis				Variance Table			
				Mean Squares			
Source of Variation:	D/F:					Beets:	
		Recov.	Sugar			per	Leaf
		Sugar	Roots	Per T.	Sucrose	Purity	100':Spot
Between Rows	: 5 :	615,778	: 6.15:	309	:1.0462	:0.6554:	67 :
Between Columns	: 5 :	686,756	: 9.69:	250	:0.5669	:2.9495:	35 :
Between Varieties	: 5 :	1411,833	:21.48:	111	:0.4052	:1.2653:	217 :
Remainder (Error)	:20 :	279,739	: 3.01:	147	:0.3733	:0.3684:	48 :
Total	:35 :						
Calculated F. Value:		5.05	:7.14 :	N.S.	: N.S.:	3.43	:4.50 :

Standard Footnotes a., and b. on page 328.

AGRONOMIC EVALUATION TEST

Conducted by: John Niederer

Location: Leo Groulx - Munger, Michigan

Cooperation: F&M Beet Sugar Assn. - Monitor Sugar Company

Date of Planting: April 16, 1966

Date of Harvest: October 24, 1966

Experimental Design: 6 x 6 Latin Square

Size of Plots: 4 rows x 28' long x 28" between rows.

Harvested Area per Plot for Root Yield: 4 rows 28' long.

Samples for Sucrose Determination: One 10 beet sample taken before harvest, 10 beets were taken consecutively in a row where they were growing competitively.

Stand Counts: Harvested beets were counted when weighed.

Recent Field History: 1964 - Wheat - 300# 5-20-20
In fall 800# 12-12-12 for beets but
didn't get them in
1965 - Beans - 300# 10-20-10

Fertilization of Beet Crop: 800# 5-20-20

Black Root Exposure: None

Leaf Spot Exposure: None

Other Diseases and pests: Root Aphids

Soil and Seasonal Conditions: Dry at planting time. Less than normal rainfall during growing season.

Reliability of Test: Good

Cooperator: F&M Beet Sugar Association - Monitor Sugar Co. Year 1966

Location: Leo Groulx Farm Munger, Michigan Exp. 1001

6 X 6 Latin Square

Variety	Recov. Sugar per A. ^a Lbs.	Roots per Acre Tons	Sugar per ^a Ton Lbs.	Sucrose ^a %	Purity ^a %	Beets per 100' No.	Leaf ^b Spot Rating
SL(129x133)msXSP5822-0	4153	13.3	312	17.40	94.18	103	
(SP6121xEL31)msXSP5822-0	4008	13.2	304	17.02	94.10	104	
SL(129x133)msXSP6322-0	4511	14.1	319	17.66	94.57	106	
(SL129xSP6121)msXSP6428-0	4036	12.9	312	17.29	94.55	100	
(SL126xSP6121)msXSP6428-0	3886	12.2	319	17.70	94.56	100	
SP5822-0	3585	11.5	310	17.46	93.85	100	
General Mean	4030	12.9	313	17.42	94.30	102	
S.E. Var. Mean	240.14	0.63	.6311	.3450	.2757	2.28	
Above as % Gen. Mean	5.96	4.90	0.20	1.98	0.29	2.24	
LSD 5% Point	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	

Latin Square Analysis			Variance Table				
	:	:	Mean Squares				
Source of Variation:	D/F:	:	:	:	:	:	Beets:
	:	Recov.	:	Sugar	:	:	per :Leaf
	:	Sugar	:Roots:	per T.:	Sucrose:	Purity:	100':Spot
Between Rows	: 5 :	197,959	: 0.48:	411	:0.6015	:2.4284:	100 :
Between Columns	: 5 :	185,574	: 0.67:	555	:1.1761	:1.0630:	68 :
Between Varieties	: 5 :	558,566	: 4.92:	197	:0.3828	:0.5599:	44 :
Remainder (Error)	:20 :	346,088	: 2.41:	239	:0.7144	:0.4562:	31 :
Total	:35 :		:	:	:	:	:
Calculated F. Value:	:	N.S.	: N.S.:	N.S.	: N.S.	: N.S.	: N.S.:

Standard Footnotes a, and b. on page 328.

AGRONOMIC EVALUATION TEST

Conducted by: John Neiderer

Location: Walter Helmrieck - Bay City, Michigan

Cooperation: F&M Beet Sugar Assn. - Monitor Sugar Company

Date of Planting: April 16, 1966

Date of Harvest: October 31, 1966

Experimental Design: 6 x 6 Latin Square

Size of Plots: 4 rows x 28' long x 28" between rows.

Harvested Area per plot for Root Yield: 4 rows 28' long

Samples for Sucrose Determination: 10 beet samples taken before harvest.
10 beets were taken consecutively in a row where they were growing competitively.

Stand Counts: Harvested beets counted when weighed.

Recent Field History: 1964 - Alfalfa for Seed
1965 - Beans - 320# 10-20-10 plus MN and Zn.

Fertilization of Beet Crop: 600# 12-12-12 broadcast plus 500#
8-32-16 plus MN and B. at planting time.

Black Root Exposure: None

Leaf Spot Exposure: None

Other Diseases and Pests: Noticeable yellowing of foliage very typical
of Beet Western Yellows and the accompanying leaf necrosis.

Soil and Seasonal Conditions: Soil moist at planting time. Adequate
moisture during the growing season.

Reliability of Test: Good

Cooperator: F&M Beet Sugar Association - Monitor Sugar Co. Year 1966

Location: Walter Helmrieck Farm, Bay City, Michigan Exp. 1004

6 X 6 Latin Square

Variety	Recov. Sugar per A. ^a Lbs.	Roots per Acre Tons	Sugar per Ton ^a Lbs.	Sucrose ^a %	Purity ^a %	Beets Per 100' No.	Leaf ^b Spot Rating
SL(129x133)msXSP5822-0	6801	22.9	297	16.74	93.76	110	
(SP6121xEL31)msXSP5822-0	6445	23.1	279	16.13	92.51	111	
SL(129x133)msXSP6322-0	6020	21.5	280	15.94	93.34	106	
(SL129xSP6121)msXSP6428-0	6169	21.2	291	16.27	94.16	102	
(SL126xSP6121)msXSP6428-0	6061	20.9	290	16.55	93.13	102	
SP5822-0	5837	20.7	282	16.16	93.02	105	
General Mean	6222	21.7	287	16.30	93.32	106	
S.E. Var. Mean	---	1.45	6.13	.2877	.3175	3.66	
Above as % Gen. Mean	---	6.68	2.14	1.77	0.34	3.45	
LSD 5% Point	---	N.S.	N.S.	N.S.	0.94	N.S.	

Latin Square Analysis			Variance Table				
	:	:					
	:	:					
			Mean Squares				
Source of Variation:	D/F:	:	:	:	:	Beets:	
	:	Recov.:	Sugar:	:	:	per:	Leaf
	:	Sugar:	Roots:	per T.:	Sucrose:	Purity:	100':Spot
Between Rows	: 5 :	Not	:12.70:	373	:1.0188	:0.5621:	39 :
Between Columns	: 5 :	Analyzed:	18.23:	74	:0.2595	:0.4068:	171 :
Between Varieties	: 5 :		: 6.46:	322	:0.5201	:2.0115:	85 :
Remainder (Error)	:20 :		:12.58:	226	:0.4968	:0.6049:	80 :
Total	:35 :		:	:	:	:	:
Calculated F. Value:	:		: N.S.:	N.S.	: N.S.	: 3.33 :	N.S.

Standard Footnotes a., and b. on page 328.

AGRONOMIC EVALUATION TEST

Conducted by: C. E. Broadwell - R. G. Fraser

Location: Canada & Dominion Sugar Co., Experimental Farm
Chatham, Ontario

Cooperation: Canada & Dominion Sugar Co., Ltd.

Date of Planting: April 15, 1966

Date of Harvest: September 26, 1966

Experimental Design: 6 x 6 Latin Square Design #8.

Size of Plots: 4 rows 30' long x 24" between rows.

Harvested Area per Plot for Root Yield: 4 rows x 30' long.

Samples for Sucrose Determination: One 10 beet sample was selected
at random after plot was harvested.

Stand Counts: Harvested beets counted when weighed.

Recent Field History: 1963 - Soybeans
1964 - Corn
1965 - Peas - 200# Am. Nitrate
400# 5-20-20 broadcast

Fertilization of Beet Crop: 500# 5-20-20 broadcast and worked in (O)
250# in band 3" below seed.

Black Root Exposure: None

Leaf Spot Exposure: Adjacent to last year's field which was planted
to beets two years in a row. Quite a severe epidemic.

Other Diseases and Pests: None

Soil and Seasonal Conditions: Very good seed bed moisture. Adequate
moisture during growing season.

Reliability of Test: Good.

Cooperator: C & D Sugar Co., Ltd., F & M Beet Sugar Assoc. Year 1966

Location: C & D Dover Farm, Chatham, Ontario Exp. 1008

6 x 6 Latin Square

Variety	Recov. Sugar per A. ^a Lbs.	Roots per Acre Tons	Sugar per Ton ^a Lbs.	Sucrose ^a %	C.J. Purity ^a %	Beets per 100' No.	Leaf Spot ^b Rating
SL(129x133)msX SP5822-0	4964	22.7	221	13.16	91.30	112	5.5
(SP6121xEL31)msX SP5822-0	4386	20.3	219	13.27	90.70	87	4.2
SL(129x133)msXSP6322-0	5040	21.4	239	14.17	91.33	105	5.2
(SL129xSP6121)msXSP6428-0	4520	19.6	231	13.79	91.20	103	4.7
(SL126xSP6121)msXSP6428-0	4620	20.3	227	13.61	91.01	98	4.2
SP5822-0	3968	18.5	216	13.03	90.78	91	3.0
General Mean	4583	20.5	226	13.50	91.05	99	4.4
S.E. Var. Mean	266	.94	6.39	.3176	.3906	4.49	.15
Above as % Gen. Mean	5.80	4.60	2.83	2.35	.43	4.53	3.28
LSD 5% Point	NS	NS	NS	NS	NS	14	.5

Latin Square Analysis				Variance Table			
:				:			
:				Mean Squares			
Source of Variation:D/F:				:			
:	:	Recov.	:	:	Sugar	:	:Beets:
:	:	Sugar	:Roots:	per T.:	Sucrose:	Purity:	100' :Spot
Between Rows	: 5	:556,458	:39.97:	2165	:2.8382	:15.1766	81 :.18
Between Columns	: 5	:396,807	:11.23:	269	:0.4046	:1.7654:	823 :.58
Between Varieties	: 5	:931,704	:12.25:	423	:1.1177	:0.4311:	512 :4.71
Remainder (Error)	:20	:423,708	: 5.31:	245	:0.6052	:0.9158:	121 :.13
Total	:35	:	:	:	:	:	:**:
Calculated F. Value:	:	NS	: NS :	NS	: NS	: NS	:4.22 :36.23

Standard Footnotes a, and b on page 328.

AGRONOMIC EVALUATION TEST

Conducted by: A. McClearin

Location: Western Ontario Agricultural School - Ridgetown, Ontario

Cooperation: Canada and Dominion Sugar Co., Ltd.

Date of Planting: April 15, 1966

Date of Harvest: September 30, 1966

Experimental Design: Randomized Blocks

Size of Plots: 3 rows x 20' long x 24" between rows.

Harvested Area per Plot for Root Yield: 1 row 16' long

Samples for Sucrose Determination: One 10 beet sample was selected
after plot was harvested.

Stand Counts: Harvested beets counted when weighed.

Recent Field History: 1964 - Corn 210-10-105# at planting plus 40#
of N. plowed down with stalks in the fall
of 1964
1965 - Oats 30-110-110#

Fertilization of Beet Crop: 176-88-38 # broadcast

Black Root Exposure: None

Leaf Spot Exposure: None

Other Diseases and Pests: None

Soil and Seasonal Conditions: Adequate moisture at planting time
and throughout the growing season.

Reliability of Test: Good

F&M SUGAR BEET VARIETY TRIAL - 1966

W.O.A.S., Ridgetown

Variety	Tons/A	% Sucrose in Beets	C. J. Purity	<u>Recoverable Sugar</u>	
				Lbs./T.	Tons/A.
SL(129x133)msXSP6322-0	29.5	15.93	94.40	281.7	4.16
5822	24.7	15.79	94.58	280.6	3.47
129x6121X6428	25.9	15.79	93.39	272.9	3.53
6121xEL61G1X5822	28.8	16.30	94.17	287.3	4.14
SL126x6121X6428	26.5	15.98	94.60	283.9	3.76
SL(129x133)msXSP5822-0	27.1	16.16	94.55	286.7	3.88
LSD at 5% Point	3.0 T.	N.S.	N.S.	N.S.	--
C.V.	10.2%	3.2%	1.0%	4.0%	--

Date of Planting: April 15, 1966

Plot Size: 3 rows x 20' (1 row x 16' harvested)

Row width and Plant Spacing: 24" row, 1 beet/12" of row.

Fertilizer: 176-88-88# broadcast

Previous Crops and Fertilizer: 1965 - Oats - 30-110-110#
1964 - Corn - 210-105-105# at planting
plus 40# N. plowed down with stalks in
fall of 1964.

Harvest Date: September 30, 1966

Section Two: Area Evaluation

The hybrids were examined for outstanding combinations for this area as well as for general combining ability.

Specific Hybrids

Pounds sugar per acre - Although each location had significant differences, when the three locations were combined the variety by location interaction was too large to allow detection of outstanding hybrids.

Tons roots per acre - The reaction was the same as for pounds sugar per acre.

Pounds sugar per ton - (FC502/2xSP581181s1)ms X SP5822-0 significantly exceeded all but (FC502/2xSP581181s1)ms X SP59B18-0 in the combined location analysis. Although under one of its entries, SL(129x133)ms X SP6428-01 was not significantly different from the best; when its other entry was averaged in, the hybrid was significantly below the best.

Percent sucrose - In the combined location analysis (FC502/2 x SP581181s1)ms X SP5822-0 significantly exceeded all but (FC502/2x SP581181s1)ms X SP59B18-0 , (SL133xEL34)ms X SP6428-0, SL(129x133)ms X SP6428-0, and FC(502/2x505)ms X SP5822-0.

Percent Clear Juice Purity - In the combined analysis (FC502/2x SP581181s1)ms X SP5822-0 significantly exceeded all but nine other hybrids.

Leaf Spot Resistance - In the combined analysis of Ontario and Ohio (no leaf spot in the Michigan test) FC(502/2x505)ms X SP59B18-0 was significantly more resistant than all but (FC502/2xSP581181s1)ms X SP59B18-0, FC(502/2x505)ms X SP5822-0 and (FC502/2xSP581181s1)ms X SP5822-0.

GENERAL COMBINING ABILITY

General combining ability as used here refers only to the male and female combinations used; hence, may have limited general application.

Among the Fort Collins females (group 1) general combining ability across locations (combined) was exhibited for percent purity and leaf spot resistance. FC502/2xSP581181s1 was significantly better than all others in the group in purity and not significantly different from the best in leaf spot resistance. FC(502/2x505) was the most resistant. At the three locations individually, whenever general combining ability was evident, FC502/2xSP581181s1 was either the best or not significantly different from the best. This includes pounds of sugar and tons of roots per acre, pounds sugar per ton, percent sucrose, percent purity, stand and leaf spot resistance.

Among the females in group 2 across locations, there was no significant difference in pounds sugar per acre or stand. In tons of roots per acre, SP64408-1 was the best with SL129xEL33 and EL35C1xEL32 not significantly different from it. Considering pounds of sugar per ton, SL133xEL34 was the best with SL133xFC503 and SL129xSP6121 not significantly different. Percent sucrose had the same result as pounds of sugar per ton. For percent purity, SL129xSP6121 was the best with SL133xFC503 and SL133xEL34 not significantly different. The most leaf spot resistance was exhibited by SL133xFC503 with EL35C1xCL32 not significantly different. At individual locations, high pounds of sugar per acre and tons of roots per acre was given by SP64408-1; in Ontario, high sugar per ton and percent sucrose was obtained by SL133xEL34 in Ohio. The highest percent

purity in Ohio and Michigan was given by SL129xFC503. In Ontario, the most leaf spot resistant female in the group was SL133xFC503.

Considering SP5822-0 versus SP58B18-0 as pollinator, SP5822-0 was better in pounds of sugar per ton in Ohio and Michigan, was better in percent sucrose in Ohio, was better in percent purity in Ontario and Michigan as well as in combined locations, and was better in stand in Ontario and in combined locations. No significant differences were noted in pounds of sugar per acre, tons per acre, or leaf spot resistance.

Considering SP6429-0 versus SP6428-01 as pollinators, SP6428-01 was better in pounds of sugar per ton in Ohio and Michigan and the combined locations, was better in percent sucrose in the combined locations, and was better in percent purity in Ohio, Michigan and the combined locations. SP6429-0 gave the most leaf spot resistance in Ontario and in the combined, however.

Considering SP6428-01 versus SP5822-0 as a pollinator for SL(129x133)ms across all 3 locations, significant difference in favor of the SP6428-01 pollinator accrued for pounds of sugar per ton and percent sucrose.

TABLE OF SEED NUMBERS BY MALE AND FEMALE PARENTS

Female + Male →	<u>SP6429-0</u>	<u>SP6428-01</u>	<u>SP5822-0</u>	<u>SP59B18-0</u>
FC505xSP581181s1 :			651201H022	651202H022
FC502/2xSP581181s1:			" H024	" H024
FC502/2xFC505 :		Group 1	" H028	" H028
SP581222s1xFC505 :			" H027	" H027
FC505xSP602116s1 :			" H017	" H017
SL(129x133) :		6528x029*	Commercial*	
SL(129x133) :		6528x029	Commercial	
SP64408-1 :	65B1x02	65B2x02		
SP64211-01 :	" x04	" x04		
SL129xEL33 :	" x05	" x05		
SL129xSP6121 :	" x06	6528x031		
SL129xFC503 :	" x07	65B2x07	Group 2	
SL133xFC503 :	" x08	" x08		
SL133xEL34 :	" x09	" x09		
CT5xSP6121 :	" x010	6528x033		
EL35C1xEL32 :	" x011	65B2x011		

* SP6528x029 and Commercial each included under 2 different entry numbers in the test.

SEED NUMBERS IN TEST WITHOUT MALE AND FEMALE COMPARISONS

MS-Female	O-Pollinator	Male	Seed Number
-----	-----	-----	SP5822-0
SP58122s1	SP581181s1	SP5822-0	SP651201H023
SP6426-01	-----	SP6428-01	SP6528x026
SP6423-01	-----	SP6428-01	SP6528x027

COMBINED ONTARIO, OHIO AND MICHIGAN OVERALL PERFORMANCE

Seed No.	% GENERAL MEAN				ACTUAL		
	Recov. Sugar per A.	Roots per Acre	Sugar per Ton	% Sucrose	% C.J. Purity	Beets per 100'	Leaf Spot
651202H022	100.9	103.4	98.0	99.0	99.4	99.6	2.95
" H024	108.9	103.1	105.7 ⁺⁺	105.3 ⁺⁺	100.2	106.3	2.00 ⁺⁺
" H028	103.3	101.3	101.9	102.4	99.7	92.0	1.90 ⁺⁺
" H027	104.7	103.3	101.3	102.0	99.7	89.2 ⁻	2.35
" H017	87.3	93.8	93.8 ⁻⁻	95.1 ⁻⁻	98.9 ⁻⁻	80.5 ⁻⁻	2.35
SP5822-0	98.2	97.4	101.3	101.3	100.0	98.7	2.75
Commercial	106.6	107.4	99.6	100.1	99.8	104.4	3.75 ⁻⁻
651201H022	100.7	98.4	102.3	101.5	100.3	110.0	2.75
" H024	103.3	96.4	107.4 ⁺⁺	105.4 ⁺⁺	101.0 ⁺⁺	105.4	2.00 ⁺⁺
" H028	108.5	103.6	104.0 ⁺⁺	103.0	100.5	103.5	2.00 ⁺⁺
" H023	95.8	95.3	101.1	101.2	100.0	104.4	2.75
" H027	97.6	95.1	102.2	101.2	100.5	103.5	2.35
" H017	103.5	101.6	101.9	101.6	100.2	98.9	2.55
Commercial	93.6	93.4	100.3 ⁺	99.4	100.4	104.5	3.55 ⁻⁻
6528x029	100.5	97.0	103.3 ⁺	102.1	100.6	99.0	3.35 ⁻⁻
65B2x02	109.1	113.2	96.6 ⁻	97.3	99.6	111.5	3.00
" x04	87.9	88.4	98.5	97.9	100.3	101.5	3.10
" x05	103.8	106.6	97.8	98.2	99.8	102.0	3.10
6528x031	96.4	94.4	102.4	100.8	100.9 ⁺	101.8	2.90
65B2x07	94.3	94.4	99.9	99.9	100.0	104.5	2.90
" x08	107.0	106.8	100.2	99.8	100.2	99.0	2.60
" x09	106.5	102.4	104.5 ⁺⁺	103.4 ⁺	100.5	104.6	3.05
6528x033	102.7	102.2	101.0	100.3	100.4	99.1	3.00
65B2x011	100.5	104.5	96.6 ⁻	98.4	99.2 ⁻	104.5	3.00
6528x026	103.8	105.7	98.3	97.9	100.2	98.2	2.65
" x027	101.7	98.8	101.7	100.4	100.6	102.9	3.25 ⁻
" x029	101.2	96.8	104.9 ⁺⁺	103.8 ⁺	100.6	98.9	2.95
65B1x02	102.2	109.4	93.6 ⁻⁻	95.8	98.9 ⁻⁻	106.2	2.85
" x04	88.5	91.7	95.7 ⁻⁻	96.4 ⁻	99.7	111.0	2.75
" x05	108.0	111.7	96.7 ⁻	98.3	99.3	102.8	2.85
" x06	93.9	93.5	100.0	99.3	100.3	101.4	2.85
" x07	99.1	101.8	97.4	98.1	99.6	98.9	2.60
" x08	95.0	94.2	100.2	100.0	100.1	99.0	2.35
" x09	98.8	98.4	100.1	99.7	100.2	96.0	2.75
" x010	88.9	93.1	95.1 ⁻⁻	96.6 ⁻	99.2 ⁻	85.2 ⁻⁻	2.50
" x011	97.4	102.3	95.2 ⁻⁻	96.7 ⁻	99.3	106.3	2.50
General Mean	5567	20.0	273.6	15.43	93.62	101.0	2.74
LSD 5%	N.S.	N.S.	2.7	3.0	0.8	10.9	0.42

+ Significant above General Mean : - Sig. below General Mean 5% Level

GENERAL COMBINING ABILITY WITHIN GROUPS

Groups + Product:Quant. :Quality:Sucrose:Purity : Stand : L.S.

<u>Females (Group 1)</u>	: 1 2 3 4:5 6 7 8:9 0 1 1 1 1 1 1 1 1 1 2:2 2 2 2:2 2 2
FC505xSP581181sl	: a n n n : A n n n : n n n : n n : a n n n : n n
FC502/2xSP581181sl	: A n n n : a n n n : n A n n : n A n n : A n n A : A n n n : n n a
FC502/2xFc505	: a n n n : n n n : n a n n : n a n n : n n : a n n n : n n A
SP581222slxFC505	: a n n n : a n n n : n n n : n n : a n n n : n n
FC505xSP602116sl	: n n n : n n n : n n n : n n : n n n : n n

Females (Group 2)

SP64408-1	: A n n n : A n n A : n n : n a : n n n n : a n
SP64211-01	: n n n : n n : n a n : n a n : n a a : n n n n : a n
SL129xEL33	: a n n n : a n n a : n a n : n a n : n : n n n n : n
SL129xSP6121	: n n n : n n : n a n a : n a n a : n A A A : n n n n : a n
SL129xFC503	: a n n n : a n n : n n : n n : n a : n n n n : a n
SL133xFC503	: a n n n : n n : n a n a : n a n a : n a a : n n n n : A n A
SL133xEL34	: a n n n : n n : n A n A : n A n A : n a a a : n n n n : a n
CT5xSP6121	: a n n n : a n n : n n : n a n : n a : n n n n : a n
EL35ClxEL32	: n n n : n n a : n n : n n : n : n n n n : a n a

Males (Group 1)

SP5822-0	: n n n n : n n n n : n A A n : n A n n : A n A A : A n n A : n n n
SP59B18-0	: n n n n : n n n n : n n : n n : n : n n : n n n

Males (Group 2)

SP6429-0	: n n n n : n n n n : n : n n n : n : n n n n : A n A
SP6428-01	: n n n n : n n n n : n A A A : n n n A : n A A A : n n n n : n

1 = Pounds sugar per acre ^{1/}	Ontario	17 = Percent C.J. Purity ^{1/}	Ontario
2 = " " " " Ohio		18 = " " " "	Ohio
3 = " " " " Michigan		19 = " " " "	Michigan
4 = " " " " Combined		20 = " " " "	Combined

5 = Tons roots per acre	Ontario	21 = Beets per 100 feet	Ontario
6 = " " " " Ohio		22 = " " " "	Ohio
7 = " " " " Michigan		23 = " " " "	Michigan
8 = " " " " Combined		24 = " " " "	Combined

9 = Pounds sugar per ton	Ontario	25 = Leaf Spot Resistance	Ontario
10 = " " " " Ohio		26 = " " " "	Ohio
11 = " " " " Michigan		27 = " " " "	Combined
12 = " " " " Combined		No " " readings in Michigan	

13 = Percent Sucrose	Ontario	n = no significant differences
14 = " " Ohio		A = best
15 = " " Michigan		a = not significantly different from the best
16 = " " Combined		blank = significantly different from the best

^{1/} Field histories on pages 347, 348 and 349.

DATA EXPRESSED AS PERCENT OF GENERAL MEAN ^{1/}

	: # Rec. Sugar/A			: Tons Roots/A			: # Rec. Sugar/Ton		
Seed No.	: Ont.	: Ohio	: Mich.	: Ont.	: Ohio	: Mich.	: Ont.	: Ohio	: Mich.
651202H022	107.6	92.9	102.2	111.8	96.3	102.2	97.5	96.5	99.9
" H024	116.3	98.7	111.7	104.6	96.1	108.5	110.8	103.3	103.0
" H028	100.0	96.7	113.1	96.7	95.4	111.8	102.9	101.7	101.2
" H027	114.5	91.6	107.9	111.1	92.8	106.1	103.1	98.9	101.8
" H017	89.6	83.2	89.0	97.3	86.7	97.3	93.8	96.0	91.5
SP5822-0	88.7	100.5	105.5	92.2	97.5	102.6	96.9	103.5	103.4
Commercial	114.4	100.0	105.5	113.7	103.4	105.0	101.8	96.6	100.5
651201H022	111.4	98.5	92.1	107.8	99.3	88.2	102.6	99.4	104.8
" H024	111.4	96.1	102.5	99.3	91.1	98.7	111.6	105.6	104.9
" H028	105.1	108.5	111.8	101.3	102.3	107.3	101.7	106.1	104.3
" H023	93.0	96.0	98.5	94.1	96.9	94.9	100.5	99.0	103.8
" H027	106.0	93.1	93.6	103.9	91.5	89.8	101.4	101.1	104.0
" H017	93.0	103.3	114.2	91.5	101.4	111.9	102.0	101.8	101.9
Commercial	81.6	100.5	98.7	84.3	95.8	100.1	97.2	105.0	98.6
6528x029	95.1	106.8	99.7	91.5	102.1	97.5	102.9	104.7	102.2
65B2x02	119.2	108.4	99.7	122.9	114.2	102.6	97.4	95.0	97.4
" x04	85.6	106.8	71.3	85.6	106.5	73.2	98.7	100.2	96.5
" x05	107.1	106.9	97.5	111.1	106.9	101.8	96.7	100.6	96.0
6528x031	93.4	95.8	100.0	92.2	92.7	98.4	102.9	103.1	101.2
65B2x07	95.8	86.3	100.7	94.8	88.5	99.8	102.1	96.7	100.9
" x08	103.1	109.4	108.5	105.2	107.4	107.9	98.4	102.0	100.2
" x09	95.8	119.4	104.2	93.5	114.6	99.2	103.8	104.3	105.3
6528x033	108.9	106.5	92.7	109.2	105.9	91.4	100.8	100.7	101.4
65B2x011	88.8	104.5	108.1	96.1	108.6	108.7	94.2	96.1	99.5
6528x026	111.0	108.3	92.1	118.3	106.2	92.7	93.4	101.8	99.6
" x027	91.8	101.6	111.8	87.6	99.3	109.5	100.8	102.4	102.0
" x029	85.0	108.7	109.9	81.7	101.9	106.7	105.6	106.6	102.4
65B1x02	106.8	103.0	96.9	111.8	114.7	101.6	95.7	89.8	95.3
" x04	80.0	95.9	89.5	85.0	98.0	92.2	92.9	97.5	96.8
" x05	117.0	97.4	109.7	119.6	100.6	114.8	97.9	96.3	96.0
" x06	97.6	97.1	87.0	96.1	96.6	87.8	100.5	100.4	99.1
" x07	109.7	99.9	87.7	112.4	101.6	91.4	97.4	98.4	96.3
" x08	93.4	102.8	88.7	92.2	102.1	88.4	100.3	100.4	100.0
" x09	100.5	93.9	102.1	99.3	94.4	101.6	100.3	99.5	100.4
" x010	93.6	84.9	88.2	95.4	90.3	93.5	97.1	94.0	94.3
" x011	88.1	96.3	107.8	90.8	101.1	115.0	96.8	95.2	93.6
General Mean 3650	6974	6078	15.3	23.6	21.3	239	296	286	
LSD 5%	22.9	13.5	18.1	20.6	11.7	17.1	8.2	7.0	5.9

^{1/} Field histories on page 347-350.

DATA EXPRESSED AS PERCENT OF GENERAL MEAN ::							ACTUAL		
Seed No. :	% Sucrose			% C.J. Purity ::			Leaf Spot		
	Ont.	Ohio	Mich.	Ont.	Ohio	Mich.	Ont.	Ohio	Average
651202H022	98.5	97.8	100.8	99.4	99.3	99.5	3.2	2.7	2.95
" H024	108.9	102.5	104.4	100.9	100.4	99.3	2.3	1.7	2.00 ⁺⁺
" H028	103.4	102.2	101.6	99.7	99.7	99.8	2.0	1.8	1.90 ⁺⁺
" H027	104.6	98.9	102.4	99.4	100.0	99.7	2.5	2.2	2.35
" H017	94.0	97.2	94.2	98.9	99.3	98.6	2.7	2.0	2.35
SP5822-0	98.8	102.6	102.6	99.1	100.5	100.4	3.0	2.5	2.75
Commercial	101.5	98.4	100.4	100.1	99.1	100.1	4.0	3.5	3.75 ⁻⁻
651201H022	101.9	99.7	103.0	100.3	99.8	100.9	3.2	2.3	2.75
" H024	108.7	104.2	103.3	101.4	100.7	100.8	2.2	1.8	2.00 ⁺⁺
" H028	101.2	104.4	103.4	100.2	100.9	100.4	2.5	1.5	2.00 ⁺⁺
" H023	100.3	100.8	102.5	100.1	99.2	100.6	3.2	2.3	2.75
" H027	100.3	101.0	102.4	100.6	100.1	100.8	2.5	2.2	2.35
" H017	101.5	101.1	102.1	100.2	100.4	99.9	2.8	2.3	2.55
Commercial	96.9	103.1	98.3	100.1	101.0	100.2	4.3	2.8	3.55 ⁻⁻
6528x029	101.9	103.4	100.9	100.5	100.7	100.7	3.7	3.0	3.35 ⁻⁻
65B2x02	98.9	95.9	97.0	99.2	99.5	100.2	3.3	2.7	3.00
" x04	97.8	99.3	96.7	100.4	100.5	99.9	3.2	3.0	3.10
" x05	96.5	101.0	97.0	100.0	99.8	99.5	3.5	2.7	3.10
6528x031	101.4	100.7	100.2	100.8	101.3	100.5	3.3	2.5	2.90
65B2x07	103.1	96.2	100.3	99.5	100.3	100.3	3.3	2.5	2.90
" x08	98.5	101.6	99.3	99.9	100.2	100.5	3.0	2.2	2.60
" x09	102.3	103.3	104.7	100.7	100.5	100.3	3.3	2.8	3.05
6528x033	100.7	100.2	100.0	100.1	100.3	100.7	3.2	2.8	3.00 ^o
65B2x011	96.9	98.1	100.2	98.8	99.0	99.7	3.2	2.8	3.00
6528x026	94.3	100.8	98.7	99.5	100.5	100.5	2.8	2.5	2.65
" x027	99.7	100.1	101.4	100.4	101.2	100.3	3.5	3.0	3.25 ⁻
" x029	103.8	105.1	102.5	101.0	100.7	100.0	3.2	2.7	2.95
65B1x02	96.8	93.6	97.0	99.5	98.0	99.1	3.0	2.7	2.85
" x04	93.8	97.4	98.0	99.5	100.1	99.4	2.7	2.8	2.75
" x05	99.4	97.9	97.5	99.4	99.2	99.2	3.0	2.7	2.85
" x06	100.2	99.1	98.7	100.1	100.7	100.2	3.0	2.7	2.85
" x07	98.9	99.3	96.2	99.3	99.6	100.0	3.0	2.2	2.60
" x08	99.6	100.7	99.7	100.3	99.9	100.1	2.5	2.2	2.35
" x09	99.4	99.4	100.4	100.4	100.1	100.0	3.0	2.5	2.75
" x010	97.6	96.6	95.6	99.7	98.7	99.3	2.7	2.3	2.50
" x011	96.2	97.5	96.4	100.4	98.8	98.6	2.8	2.2	2.50
General Mean	13.86	16.54	15.90	92.35	94.18	94.33	3.0	2.5	2.74
LSD 5%	6.4	5.6	4.9	1.6	1.2	1.1	.6	.6	.42

AREA EVALUATION TEST ^{1/}

Conducted by: C. E. Broadwell - R. G. Fraser

Location: Canada & Dominion Sugar Co., Experimental Farm
Chatham, Ontario

Cooperation: Canada & Dominion Sugar Co., Ltd.

Date of Planting: April 15, 1966

Date of Harvest: September 26, 1966

Experimental Design: Randomized Block 6 Replications

Size of Plots: 2 rows 20' long x 24" between rows.

Harvested Area per Plot for Root Yield: 2 rows 20' long

Samples for Sucrose Determination: One 10 beet sample was selected
at random after plot was harvested.

Stand Counts: Harvested beets counted when weighed.

Recent Field History: 1963 - Soybeans
1964 - Corn
1965 - Peas - 200# Am. Nitrate
400# 5-20-20 Broadcast

Fertilization of Beet Crop: 500# 5-20-20 broadcast and worked in
250# in band 3" below seed.

Black Root Exposure: None

Leaf Spot Exposure: Adjacent to last year's field which was planted
to beets two years in a row. Quite a severe epidemic.

Other Diseases and Pests: None

Soil and Seasonal Conditions: Very good seed bed moisture. Adequate
moisture during growing season.

Reliability of Test: Good.

^{1/} For data see pages 345 and 346.

AREA EVALUATION TEST ^{1/}

Conducted By: John Niederer

Location: Willard Jones - Ottawa, Ohio

Cooperation: F&M Beet Sugar Assn. - Buckeye Sugars, Inc.

Date of Planting: April 14, 1966

Date of Harvest: November 15, 1966

Experimental Design: Randomized Block - 6 replications

Size of Plots: 2 rows x 20' long x 30" between rows

Harvested Area per Plot for Root Yield: 2 rows x 20' long

Samples for Sucrose Determination: One 10 beet sample was taken during harvest. Beets were selected at random from the plot.

Stand Counts: Harvested beets were counted when weighed.

Recent Field History: 1964 - Wheat 100# 8-32-16 at planting and 150#
6-24-12 in the fall

1965 - Beans

Fertilization of Beet Crop: 350# 8-32-16 broadcast plus 125# 8-32-16
at planting. (C)

Black Root Exposure: Slight

Leaf Spot Exposure: Slight

Other Diseases and Pests: None

Soil and Seasonal Conditions: Seed bed was moist at planting time.

Adequate moisture during growing season.

Reliability of Test: Good.

^{1/} For data see pages 345 and 346.

AREA EVALUATION TEST ^{1/}

Conducted by: John Niederer

Location: Walter Helmrieck - Bay City, Michigan

Cooperation: F&M Beet Sugar Assn. - Monitor Sugar Company

Date of Planting: April 16, 1966

Date of Harvest: October 31, 1966

Experimental Design: Randomized Block 6 Replications

Size of Plots: 2 rows 20' long x 28" between rows.

Harvested Area per Plot for Root Yield: 2 rows 20' long

Samples for Sucrose Determination: One 10 beet sample taken prior to harvest from each plot. 10 beets were taken consecutively in a row where they were growing competitively.

Stand Counts: Harvested beets counted when weighed.

Recent Field History: 1964 - Alfalfa for seed
1965 - Beans - 320# 10-20-10 plus MN plus ZN.

Fertilization of Beet Crop: 600# 12-12-12 broadcast plus 500# 8-32-16 plus MN plus B. at planting time.

Black Root Exposure: None

Leaf Spot Exposure: None

Other Diseases and Pests: Noticable yellowing of foliage very typical of Beet Western Yellows and the accompanying leaf necrosis

Soil and Seasonal Conditions: Soil moist at planting time. Adequate moisture during the growing season.

Reliability of Test: Good.

^{1/} For data see pages 345 and 346.

AGRONOMIC EVALUATION TEST, 1966

USDA Varieties

Conducted by: Phil B. Brimhall, H. L. Bush, R. K. Oldemeyer and D. L. Sunderland

Location: Glen Haas Farm, Fremont, Ohio

Cooperator: Northern Ohio Sugar Company, Fremont, Ohio

Date of Planting: May 27, 1966

Date of Harvest: November 21, 1966

Experimental Design: Simple Lattice Design

Size of Plots: 1 row x 24 feet x 8 replicates
30-inch row spacing

Harvest Area per Plot: 1 row x 18 feet

Samples for Sucrose and Purity Determinations: 1 sample per plot

Stand Counts: Beets counted in laboratory

Recent Field History: Sugar beets (1965) spring plowed

Fertilization of Beet Crop: 400 pounds 8-32-16 plow-down
150 pounds 6-24-12 starter fertilizer

Leaf Spot Exposure: Not enough present for readings

Black Root Exposure: Early seedling stage mild; however, Aphanomyces was a chronic factor throughout the growing season.

Curly Top Exposure: None noted

Other Diseases: None noted

Soil and Seasonal Conditions: Soil surface dry and cloddy at planting time, very wet at $2\frac{1}{2}$ inches. Beet emergence good, beets stunted due to 6 inches precipitation, July 11 and 12. Moisture adequate to excessive throughout growing season. Soil was a heavy clay loam.

Cooperator: Northern Ohio Sugar Company by Phil Brimhall, H. L. Bush,
R. K. Oldemeyer, D. L. Sunderland

Location: Glen Haas Farm, Fremont, Ohio

Year: 1966

(Results given as 8 plot averages in % of SP5822-0)^(f)

Strain	Recoverable ^(c)	Root Yield	Sugar Content	Thin Juice	Black ^(a) Root	Beets ^(b) per 100 ft.
	Sugar Yield			App. Purity		
SP6528 x 026	129.07 ⁺	132.29 ⁺	99.25	98.79	2.4	124
SP6528 x 027	116.83	113.68	100.38	101.34	2.9	126
SP6528 x 030	115.27	113.88	100.68	99.95	2.6	125
SP6528 x 031	109.88	107.27	100.47	100.37	2.3	128
SP6528 x 033	113.63	111.90	99.35	101.22	2.1	116
SP6528 x 034	115.24	113.06	101.63	99.80	2.3	128
SP6528 x 027	112.58	114.88	99.31	99.00	2.6	110
SP65180 x 032	108.51	108.89	99.93	99.61	2.8	117
SP65180 x 027	112.20	109.48	102.24 ⁺	99.87	2.8	126
SP65363-01	109.26	107.25 ⁺	100.38	100.28	3.0	115
SP65363-02	119.86 ⁺	121.39 ⁺	99.69	99.34	2.4	137
SP65499-01	95.08	93.35 ⁺	101.28	100.15	2.8	105
SP653170 x 027	127.72 ⁺	130.74 ⁺	99.64	98.53	2.5	136
SP653170 x 032	119.61 ⁺	121.35 ⁺	100.12	99.10	3.0	122
SP65B1 x 02	113.33	117.65 ⁺	98.75	98.74	3.1	143
SP65B2 x 02	113.66	117.13	97.87	99.33	2.4	134
SP65B1 x 06	100.34	99.74	100.99	99.31	2.8	128
SP65B1 x 09	98.36 ⁺	94.98 ⁺	102.81 ⁺	100.25	3.5	123
SP65B2 x 09	117.56 ⁺	119.17 ⁺	101.48 ⁺	98.66	2.9	144
SP65B3 x 09	117.90 ⁺	110.63	103.81 ⁺	101.03	3.4	119
SP65B3 x 02	100.55	98.97	102.42 ⁺	99.59	3.4	139
SP65B2 x 08	102.39	100.98	100.64 ⁺	100.47	2.9	139
SP65B3 x 08	111.22	106.89 ⁺	103.84 ⁺	100.27	2.6	125
SP65B3 x 011	119.22 ⁺	120.80 ⁺	102.81 ⁺	97.93	2.9	144
CV (%)	15.66	16.21	2.17	2.93	-	-
Sm/Gen. M (%)	5.54	5.73	0.77	1.04	-	-
LSD 5% pt. (% of 5822-0)	16.65	17.33	2.20	2.85	-	-

Location: Glen Haas Farm, Fremont, Ohio

Year: 1966

Variance Table

Source of Variance	DF	Mean Squares			
		Recoverable ^(a) Sugar (lbs.)	Roots ^(d) (lbs.)	Sucrose (%)	Purity (%)
Replicates	7	7.3687	402.06	3.7204	19.0401
Varieties	48	2.1069	84.31	0.5829	8.7884
Random Block Error	330	0.6110	24.02	0.1657	7.9046 ^(e)
Blocks (elim. var.)	48	0.7874	30.99	0.2287	7.3278
Component a	36	0.8739	34.82	0.2092	8.1528
Component b	12	0.5278	19.49	0.2873	4.8529
Intra-Block Error	282	0.5810 ^(e)	22.85 ^(e)	0.1552 ^(e)	8.0025
Total	385	0.9204	38.22	0.2805	8.2165

(a) 0 = No black root apparent, 10 = complete necrosis due to black root

(b) Harvest stand

(c) Calculated (from formula used since 1953) by electronic computer

(d) Pounds per plot

(e) Error term used

(f) Mean for 3 plots SP5822-0 = 4433 lbs. Recoverable Sugar, 13.36 Tons Roots per A,
18.01% Sucrose, 96.76% Purity.

+ Significantly above SP5822-0 at 5% pt.

- Significantly below SP5822-0 at 5% pt.

Cooperator: Northern Ohio Sugar Company by Phil Brimhall, H. L. Bush,
R. K. Oldemeyer, D. L. Sunderland

Location: Alvin Heilman Farm, Old Fort, Ohio

Year: 1966

(Results given a 8 plot averages in % of SP5822-0)^(f)

Strain	Recoverable ^(c)		Sugar Content	Thin Juice App. Purity	Leaf ^(a) Spot	Beets ^(b) per 100 ft.
	Sugar Yield	Root Yield				
SP65B1 x 010	123.86 ⁺	124.22 ⁺	97.42	100.93	3.0	127
SP6528 x 027	120.13 ⁺	122.09 ⁺	97.59	100.31	3.6	119
SP6528 x 030	104.87	107.92	98.66	99.26	3.8	121
SP6528 x 031	109.23	112.12	99.18	98.95	4.0	119
SP6528 x 033	102.05	109.50	97.80	97.91	3.8	126
SP6528 x 034	100.84	104.75	97.19	99.60	4.8	113
SP65180 x 027	105.90	110.03	95.45 ⁻	100.23	3.4	117
SP65180 x 032	113.68	115.29	99.38	99.50	2.6	129
SP65190 x 027	112.92	112.82	97.40	100.86	3.6	120
SP65363-01	97.72	102.89	94.52 ⁻	100.16	4.1	113
SP65363-02	106.08	110.27	95.52 ⁻	100.30	4.3	113
SP65499-01	96.25	103.92	96.30 ⁻	98.09	4.1	119
SP653170 x 027	110.32	110.93	98.01	100.29	2.8	115
SP653170 x 032	111.49	111.69	98.25	100.57	3.0	113
SP65B1 x 02	99.70	105.74 ⁺	94.80	99.39	3.4	117
SP65B2 x 02	114.11 ⁺	116.86 ⁺	98.62	99.38	3.1	122
SP65B1 x 06	118.41 ⁺	118.19 ⁺	98.93	100.31	3.3 ^o	129
SP65B1 x 09	105.06	110.46	98.52	98.65	4.1	126
SP65B2 x 09	106.71	108.16	98.20	100.61	4.0	126
SP65B3 x 09	101.05	99.40	101.03	100.44	4.1	139
SP65B1 x 04	109.39	109.22	99.73	100.35	4.0	128
SP65B3 x 04	100.22	105.10	96.35 ⁻	99.38	4.1	111
SP65B1 x 05	105.56	113.00	97.74	99.00	3.9	126
SP65B1 x 010	104.21	109.13	95.36 ⁻	99.99	3.8	127
CV (%)	15.77	14.50	3.57	2.69	-	-
Sm/Gen. M (%)	5.57	5.13	1.26	0.95	-	-
LSD 5% pt. (% of 5822-0)	16.43	16.23	3.52	2.67	-	-

Footnotes and Variance Table, page 354.

Field history, page 355.

Location: Alvin Heilman Farm

Year: 1966

Variance Table

Source of Variance	DF	Mean Squares			
		Recoverable ^(a)	Roots ^(d)	Sucrose	Purity
		Sugar (lbs.)	(lbs.)	(%)	(%)
Replicates	7	6.7359	254.74	8.6763	15.6563
Varieties	48	1.7350	72.65	3.0400	10.4870
Random Block Error	331	0.9049	44.77	0.3990	6.3403
Blocks (elim. var.)	48	1.1360	59.41	0.7737	8.6443
Component a	36	1.2467	60.85	0.8554	8.6033
Component b	12	0.8038	55.10	0.5288	8.7675
Intra-Block Error	283	0.8647 ^(e)	42.29 ^(e)	0.3354 ^(e)	5.9396 ^(e)
Total	386	1.1177	52.05	0.8775	7.0375

(a) 0 = No evidence of disease, 10 = complete necrosis due to leaf spot.

(b) Harvest stand

(c) Calculated (from formula used since 1953) by electronic computer

(d) Pounds per plot

(e) Error term used

(f) Mean for 3 plots SP5822-0 = 5470 lbs. Recoverable Sugar per A, 19.44 Tons
Roots per A, 16.98% Sucrose, 91.57% Purity,
3.2 Leaf Spot.

+ Significantly above SP5822-0 at 5% pt.

- Significantly below SP5822-0 at 5% pt.

Variance Table -- Data, page 353.

Field history, page 355.

AGRONOMIC EVALUATION TEST, 1966

USDA Varieties

Conducted by: Phil B. Brimhall, H. L. Bush, R. K. Oldemeyer and D. L. Sunderland

Location: Alvin Heilman Farm, Old Fort, Ohio^{1/}

Cooperator: Northern Ohio Sugar Company, Fremont, Ohio

Date of Planting: April 13, 1966

Date of Harvest: October 7, 1966

Experimental Design: Simple Lattice Design

Size of Plots: 1 row x 24 feet x 8 replicates
28-inch row spacing

Harvest Area per Plot: 1 row x 18 feet

Samples for Sucrose and Purity Determinations: 1 sample per plot

Stand Counts: Beets counted in laboratory

Recent Field History: Sugar beets (1965) spring plowed

Fertilization of Beet Crop: 600 pounds 13-13-13 plow-down
150 pounds 6-24-12 starter fertilizer

Leaf Spot Exposure: Very severe, readings taken September 6, 1966

Black Root Exposure: Mild, no loss of stand

Curly Top Exposure: None noted

Other Diseases: Lygus bug caused some damage

Soil and Seasonal Conditions: Soil and moisture conditions good for seedling emergence and growth throughout season. Soil was a sandy loam.

^{1/} Data on page 353.

An Evaluation of Seed Treatments for Controlling Sugarbeet Seedling Diseases in the Great Lakes Region

D. L. Mumford and John Niederer^{1/}

Seedling diseases of sugarbeets continue to hinder obtaining good stands in many fields in the Great Lakes Region. This is especially evident where planting is delayed and when warm moist weather accompanies emergence. All commercial seed planted in this region is routinely treated with a fungicide to reduce losses from soil-borne pathogens.

Field observation and laboratory examination during the past three years indicate that Aphanomyces cochlioides Drechsler is still the most important of several fungi causing seedling diseases in the Great Lakes sugarbeet growing area. Earlier tests both in the greenhouse and field had indicated that Dexon, a product of Chemagro Corporation, was most effective in reducing damping off by Aphanomyces. Therefore, a field test was designed to compare three rates of Dexon, Dexon in combination with Terraclor (a product of Olin Mathieson Chemical Corporation), Captan (California Chemical Company), as it is currently used in treating all seed planted in the region, and Captan in combination with two seed protectants from Dupont.

The test was planted on May 23, on the Bob Springer farm near Coleman, Michigan. The field had been in beets the previous year and had a history of blackroot. Plots were 50 feet long with eight replications per treatment. The number of healthy seedlings in the center 30 feet of each plot was determined at 14 and 28 days after planting. A similar test was planted near Ottawa, Ohio, but it was accidentally destroyed before data was obtained.

Fourteen days after planting there were significantly greater numbers of healthy seedlings with seed treatments of Dexon at four ounces per 100 pounds of seed and Dexon-Terraclor combination at the same rate than with untreated seed (Table 1). The benefit with Dexon-Terraclor was also present after 28 days. Blackroot severity was somewhat variable in the test area, probably due to a tendency for certain sites to remain moist longer after a rain. This resulted in considerable variability in results obtained, particularly after 28 days.

It would be advisable to obtain information from similar tests at other locations. However, these data along with similar unreported data obtained earlier in field and greenhouse seem to warrant consideration of Dexon-Terraclor (35%-35%) at four ounces per 100 pounds of seed in routine treatment of sugarbeet seed for the Great Lakes Region.

^{1/} Director of Research, Farmers & Manufacturers Beet Sugar Association.

Table 1. Effect of fungicide seed treatments on sugarbeet seedling emergence and survival

Fungicide	Rate/100 lbs. seed	No. healthy seedlings/240 ft. at 2 week intervals after planting	
		14 days	28 days
Captan (75%)	6 oz.	383	155
Captan-Demasan	<u>a/</u>	277	187
Captan-Demasan - 1179-95 ^{b/}	<u>a/</u>	347	188
Dexon (70%)	2 oz.	562	217
Dexon	3 oz.	584	222
Dexon	4 oz.	709	204
Dexon-Terraclor (35%-35%)	4 oz.	816	347
Check		528	244
	LSD (5%)	150	LSD (10%) 94

a/ The Demasan and 1179-95 (65W) protectants were each superimposed at a 6 oz. rate on seed previously treated with Captan

b/ 1179-95 is an insecticide

PHYSIOLOGICAL INVESTIGATIONS - 1966^{1/}

F. W. Snyder

Germination Studies²

ABSTRACT: 1. Maturity affects germination performance of Oregon grown seed. 2. Environment during seed and fruit development may affect significantly germination performance in laboratory tests. 3. Preliminary evidence from germination tests indicates that sugar-beet seeds may possess surprising tolerance to artificial heat during drying operations.

The effect of ripeness of fruits and seeds on germination performance of two varieties harvested in Oregon in 1965 is similar to that reported for seed grown in Arizona in 1964. (See 1964 Report) Seeds harvested five days early have a lower percentage of germination and tend to germinate slower than those harvested later. Performance is affected markedly by harvesting 10 days early.

A study of sugarbeet hybrid (SL 126x128)ms x SP 5822-0 seed produced at two locations in Oregon has demonstrated a significant effect of environment during seed development on germination performance (Table 1). Both lots were germinated on the same blotter. Fruits and excised seeds of both lots were examined and germinated. Judging from appearance of the fruits, lot 4426 may have been slightly less mature at harvest, but maturity cannot account for the difference in performance. Lot 4426 had a slightly greater percentage of fruits containing no seeds and badly shrivelled seeds. Lot 4426 also had slightly less vigor as indicated by length of roots of germinated excised seeds. Based on the number of seeds that actually germinated in 10 days, lot 4426 germinated significantly slower. A water extract (1:10) of the fruits of lot 4426 contained 116 milligram-percent of oxalate; lot 4504 contained only 51. The wheat growth bioassay for inhibitory substances revealed that lot 4426 was appreciably more inhibitory. The marked differential in germination performance of these two seedlots occurred only when the seeds were surrounded by the intact fruits. It appears that the slightly less vigorous seeds of lot 4426 may have been sensitive to the greater concentration of inhibitory substances in the fruits of that lot. Previous tests on lot 4426 had demonstrated that removal of the corky material from the fruits and soaking in water could increase the percentage germination up to 87 percent.

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- ^{1/} Research conducted in cooperation with Michigan Agricultural Experiment Station.
- ^{2/} Christina Filban and John M. Sebeson, Sr. assisted in this research. West Coast Beet Seed Company and Farmers and Manufacturers Beet Sugar Association provided the seed.

Table 1.

GERMINATION PERFORMANCE OF SUGARBEET HYBRID, (SL 126x128)ms x SP5822-0,
GROWN AT TWO LOCATIONS IN OREGON

Lot No.	Fruit Size Inches/64	Good Seeds Percent	Germination in 10 days* Percent
4426	on 10	89	43.5
4504	on 10	96	95.0
4426	on 8 1/2	70	21.1
4504	on 8 1/2	79	91.5

* Based on good seeds, i.e., corrected for fruits containing no seed and for partially developed seeds that were judged to be non-viable.

Table 2.

EFFECT OF SELECTION OF SUGARBEET MOTHER ROOTS FOR ROOT/SHOOT RATIO
ON THE ROOT/SHOOT RATIO OF THE PROGENIES

Root/Shoot Ratios				
Group	Mother Roots		Progenies	
	Avg.	Range	Avg.	Range
Lowest*	0.39	0.31-0.44	0.81	0.73-1.02
Highest**	0.68	0.65-0.72	1.26	1.04-1.43
Lowest/Highest	0.57		0.64	
Crown/Root Ratio				
Lowest*	0.39	0.26-0.50	0.19	0.14-0.22
Highest**	0.22	0.18-0.27	0.11	0.08-0.14
Lowest/Highest	1.77		1.73	

*10 roots and lines tested

**6 roots and lines tested

In a cooperative study³ of the effect of drying temperature on germination performance of sugarbeet seeds, seeds harvested from individual plants of both monogerm and multigerm varieties were dried at temperatures from 90 to 130 degrees F. Moisture contents of samples (dried at 130 degrees F.) from the individual plants ranged from 9.85 to 198.54 percent. Only two of 15 samples germinated less than 93 percent. Three samples which ranged in moisture content from 58 to 198 percent moisture were dried at 130 degrees F. All three of them germinated better than 93 percent and were not adversely affected by the high temperature as compared with drying at lowest temperatures.

Thin layer chromatography is an excellent technique to attempt to identify the inhibitors in sugarbeet fruits. Although identifications have not been fully completed, at least one new substance has been tentatively identified.

Root-Shoot Ratio Study⁴

ABSTRACT: The ratio of root to shoot and crown to root seems to be genetically controlled, however, as indicated in the 1964 Report, nitrogen fertilization may influence the ratio to some degree.

Definitions as used in this report are: Shoot is defined as all of the sugarbeet plant above the lowest leaf scar. Root is that portion of the plant below the lowest leaf scar. Crown is that portion of the plant between the base of the leaves and the lowest leaf scar.

In 1964, 96 plants of Hogaboam's 02-clone were screened by a water displacement procedure to obtain the highest and lowest root-shoot ratios. Seed was obtained from each mother root in 1965. In 1966, a 120 feet of row was planted with seed obtained from each of 10 mother roots that had the lowest root-shoot ratio and from seed obtained from each of 6 mother roots that had the highest root-shoot ratio. With one exception, 25 plants were harvested for each progeny. The total weight, root weight, crown weight, and leaf weight were determined for each progeny. The data (Table 2) indicate a rather high degree of constancy and almost complete separation of the groups.

3/ Paul Bergdolt, Graduate Assistant, Agricultural Engineering, Michigan State University, East Lansing, Michigan designed the equipment and did the drying.

4/ Cooperative with G. J. Hogaboam and Richard C. Zielke.

DEVELOPMENT OF BREEDING MATERIAL RESISTANT TO LEAF SPOT AND BLACK ROOT

G. E. Coe

Work under Foundation Project 26, at the Plant Industry Station, Beltsville, Maryland is directed mainly toward varietal improvement in resistance to *Cercospora* leaf spot and *Aphanomyces* black root.

This part of the report will cover trends in the performance of basic breeding material, leaf spot tests of some experimental hybrids and some new monogerm type 0 lines, and a method for increasing the severity of leaf spot in the nursery tests.

Trends in Basic Breeding Stocks

The trends of the basic breeding stocks in disease resistance and in agronomic characteristics as compared to the performance of the standard check variety, US 401, are presented in graph form. Graphs 1 thru 8 provide comparison of the performance of US 401 with the average performance of all the multigerm and monogerm lines tested. The performance of US 401 was arbitrarily given a numerical value of 100 each year for each characteristic investigated. Ratings higher than 100 indicate that the performance of the breeding lines was better than US 401; ratings less than 100 indicate that the breeding lines did not perform as well as US 401. For percentage soluble nonsugar solids, a rating greater than 100 indicates a lower percentage of soluble nonsugar solids than US 401, and hence better performance with respect to this characteristic.

In 1966, the performance of both the multigerm and monogerm breeding lines bounced back some from 1965's apparent decline on leaf spot resistance. Year to year fluctuations in leaf spot resistance relative to the resistance of US 401 are to be expected. The performance in any one year may deviate some from the long-term performance trend. If one examines the leaf spot performance in Graphs 1 and 2 from 1961 thru 1964, one might conclude that rapid progress was made in improving *Cercospora* leaf spot resistance. However, if one includes the performances of the breeding lines in 1965 and 1966, a different conclusion is reached: namely, that the rate of improvement in resistance from 1961 through 1966 was no greater than previous rates of improvement. Conditions in the test years of 1962, 1963 and 1964 appear to have been relatively disadvantageous for the standard check variety, US 401, making the breeding lines appear relatively more resistant. However, the actual rate of improvement in resistance to *Cercospora* leaf spot has probably been fairly constant.

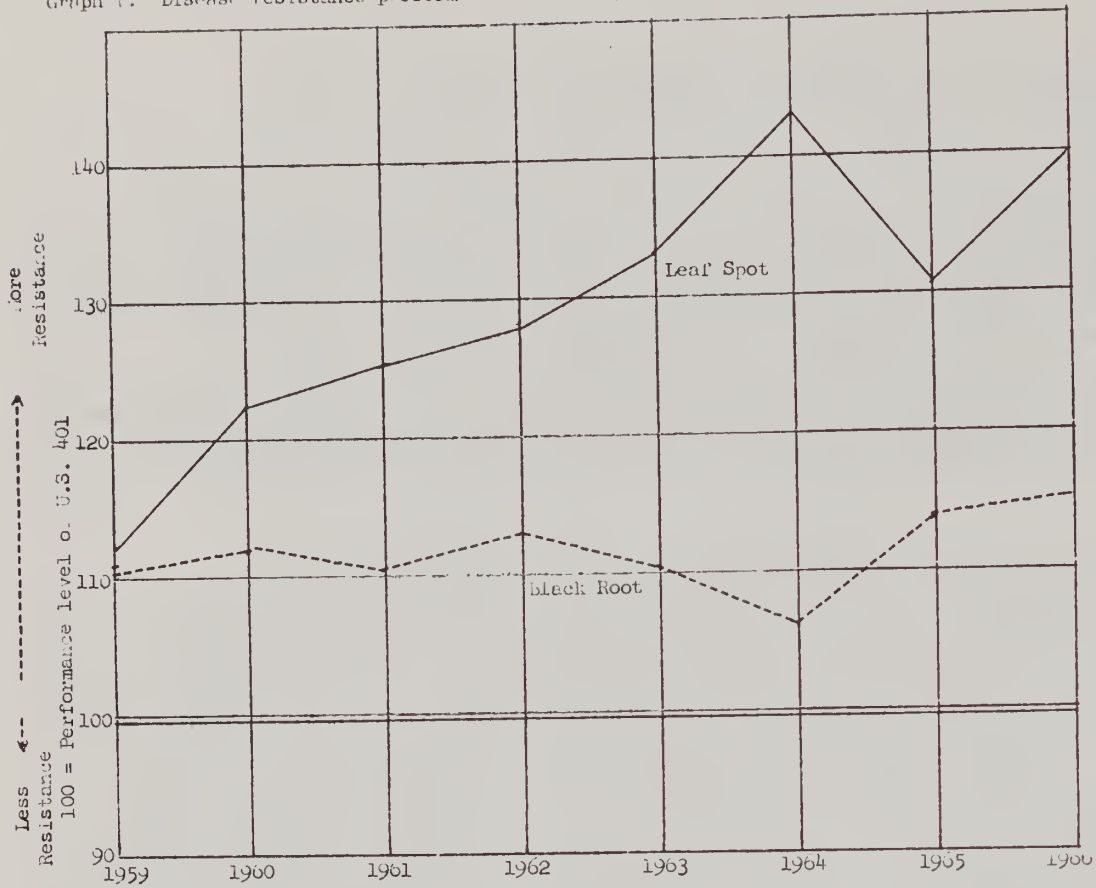
It was pointed out in a previous report that the rate of improvement in resistance to *Aphanomyces* root rot is difficult to evaluate, because it has been necessary to increase the dosage of inoculum as the resistance of the breeding material increases. A resistant sugarbeet variety can

tolerate relatively low dosages of inoculum, but once a certain dosage threshold is reached, the plants begin to show marked and severe symptoms. Increased amounts of inoculum cause some increase in disease severity but relatively little as compared to the reaction observed immediately after exceeding the tolerance threshold of the variety. Graphs 1 and 2 indicate only a slight improvement in black root resistance in the last seven years. However, this is a measure of improvement in tolerance after the tolerance threshold levels of the varieties has been exceeded. In commercial sugarbeet areas, it is probably only rarely that black root severity exceeds the tolerance threshold level of our more resistant breeding lines. It appears that greater levels of resistance can and will be achieved, and that varieties with virtual field immunity to this disease will be developed.

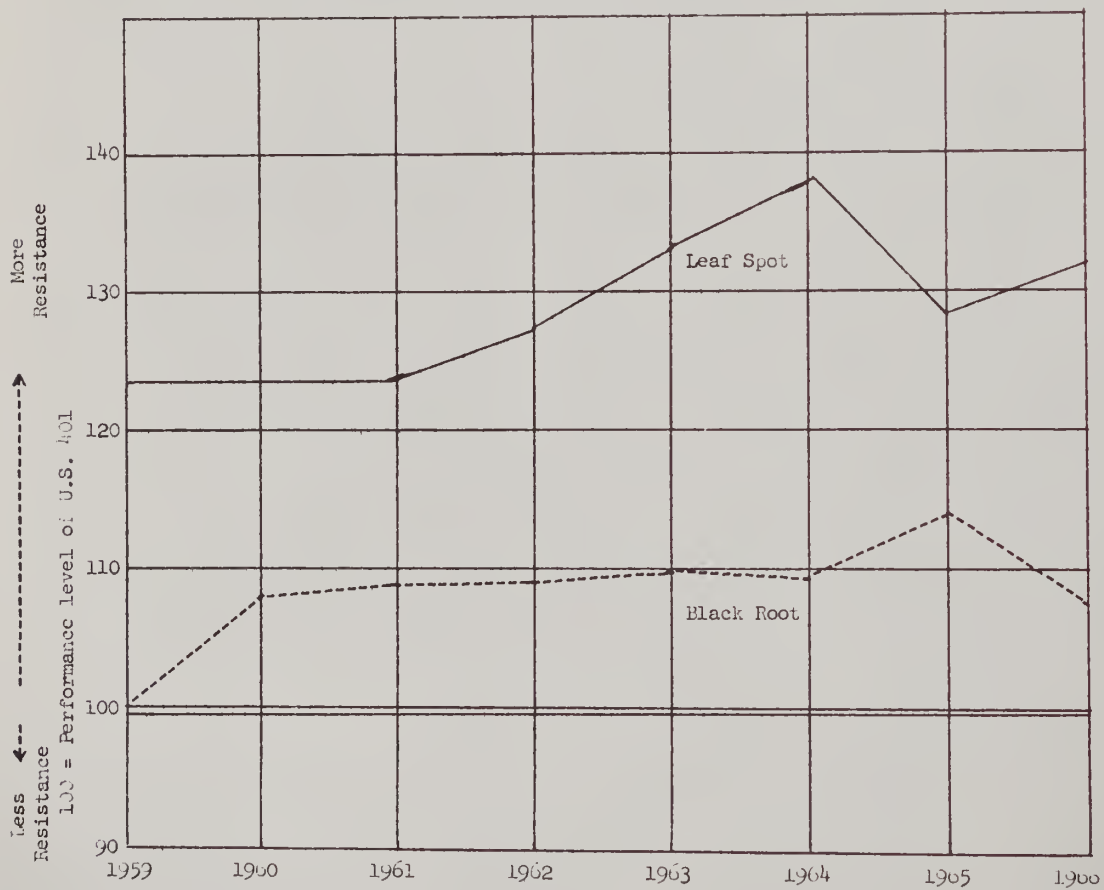
The root yield of the multigerm breeding lines at Beltsville has decreased considerably in relation to the root yield of US 401 each year for the last 3 years, and has been 3 to 4% less than US 401 at East Lansing (Graph 3). This tendency toward lower yield is real and is a consequence of applying heavy selection pressure for other characteristics and of close breeding. Although decreases in root weight of the breeding lines as a whole are not desirable, it is anticipated that some of these lines will have sufficient combining ability to give maximum yields when used as a parent in the production of hybrids. On the other hand, root yield must now be carefully watched, and perhaps given greater preference in future selections. In 1965 and 1966, the monogerm lines showed a decline in yield as compared to US 401 at Beltsville. At East Lansing, a great increase in the root yield and sugar percentage of the monogerm lines occurred in 1966 as compared to US 401. However, the East Lansing data are from only a few of the better monogerm lines and do not represent the true status of the general run of monogerm lines. (See Graph 4).

The decreases in root yield at Beltsville make one skeptical of the increases in sugar percentage, because of the inverse relationship between root weight and percent sugar. However, a closer examination of the data revealed that both the multigerm and monogerm lines tested for sugar content were heavier than the average of all the lines in the test plot. The multigerm lines tested for sugar percentage have a root yield numerical rating of 120 in 1966 compared to 108 for all multigerm lines; and the monogerm lines tested for sugar percentage had a numerical root yield rating of 130 compared with 102 for all the monogerm lines. These comparisons indicate that the improvement in sugar percentage is not attributable to small root size, but rather to improved leaf spot resistance and to improved potential for sucrose production under Beltsville conditions. The potential for greater sucrose production at Beltsville, however, is usually not attained when these varieties are grown in areas further north where climatic conditions are ordinarily more favorable for the production of higher sugar percentages. (See Graphs 5 and 6).

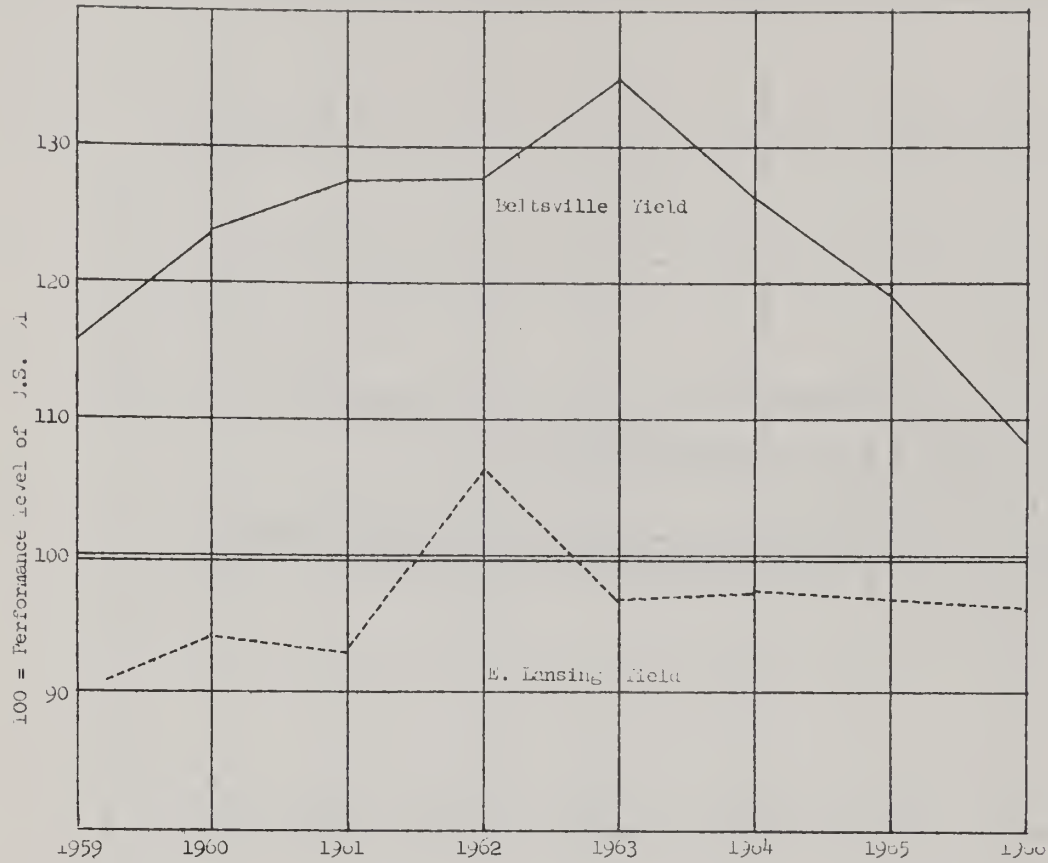
Graph 1. Disease resistance performance of multigerm breeding lines.



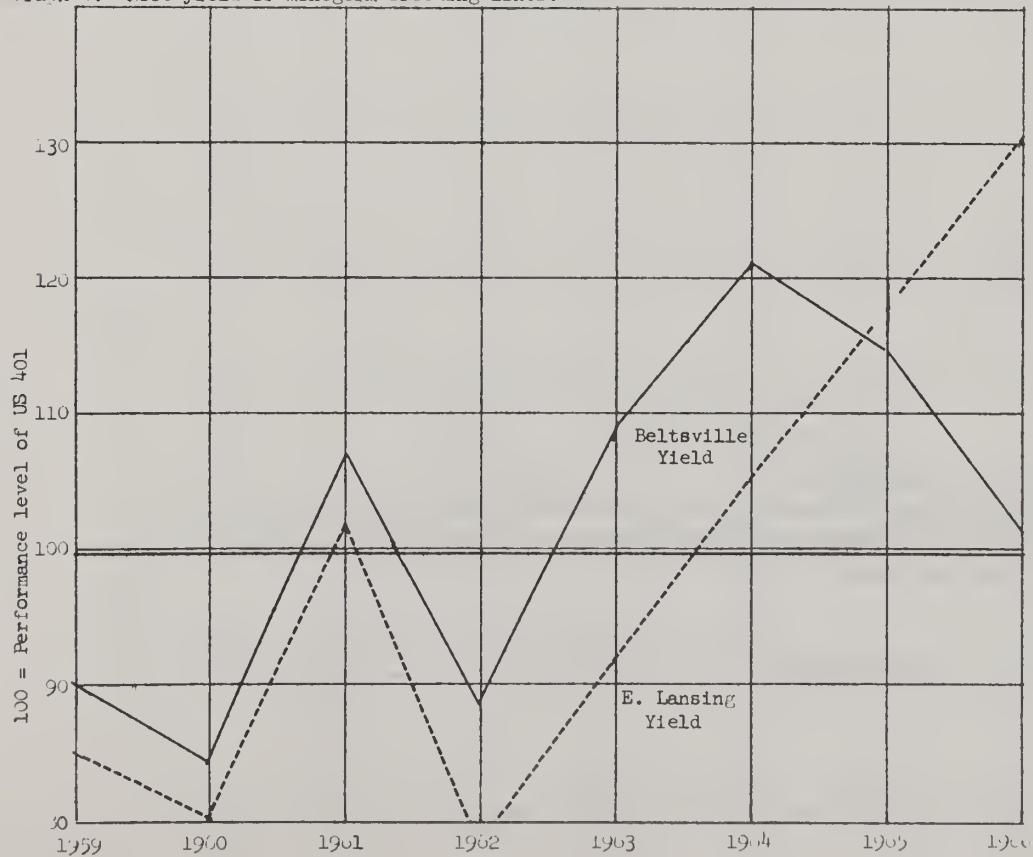
Graph 2. Disease resistance performance of monogerm breeding lines.



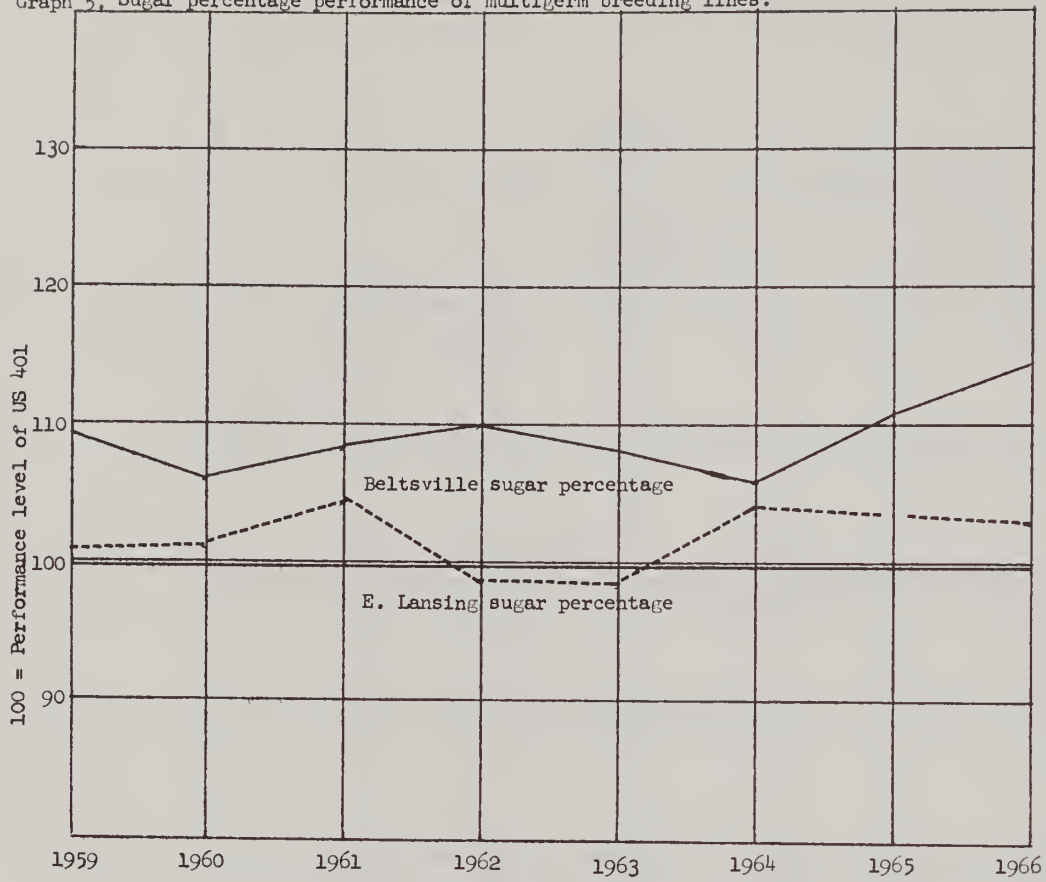
Graph 3. Root yield of multigerm breeding lines.



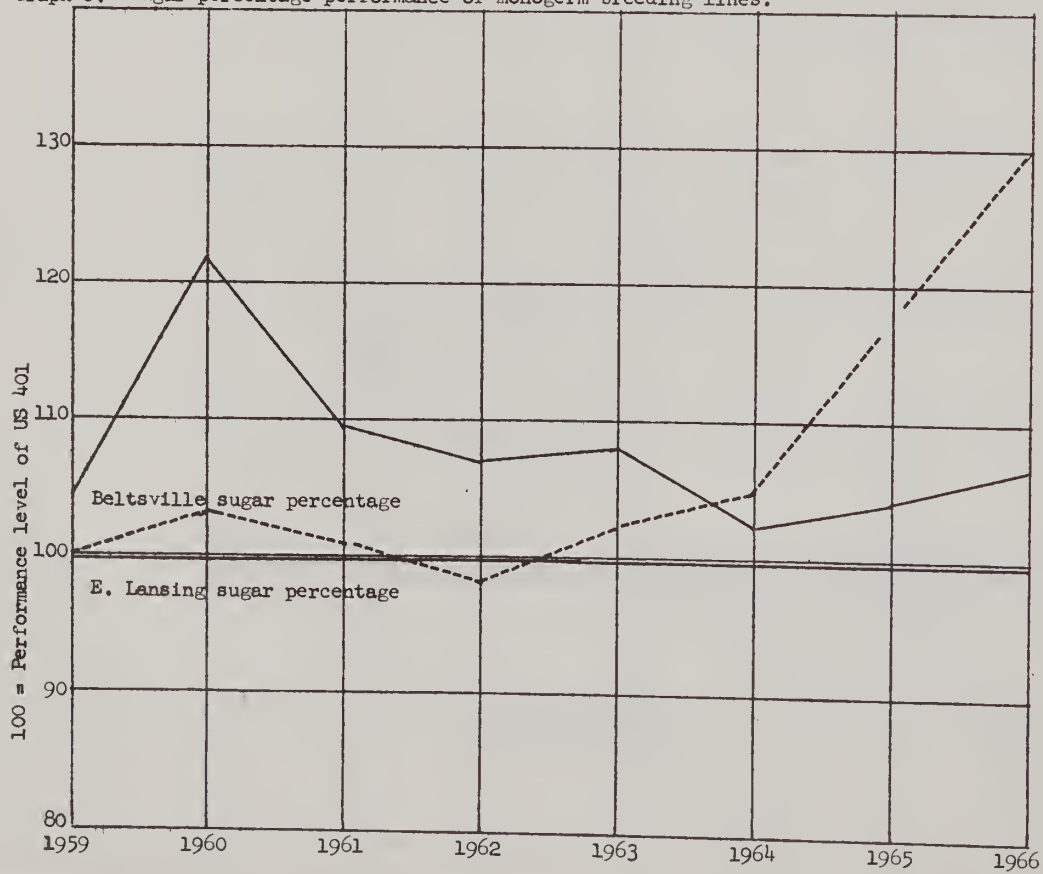
Graph 4. Root yield of monogerm breeding lines.



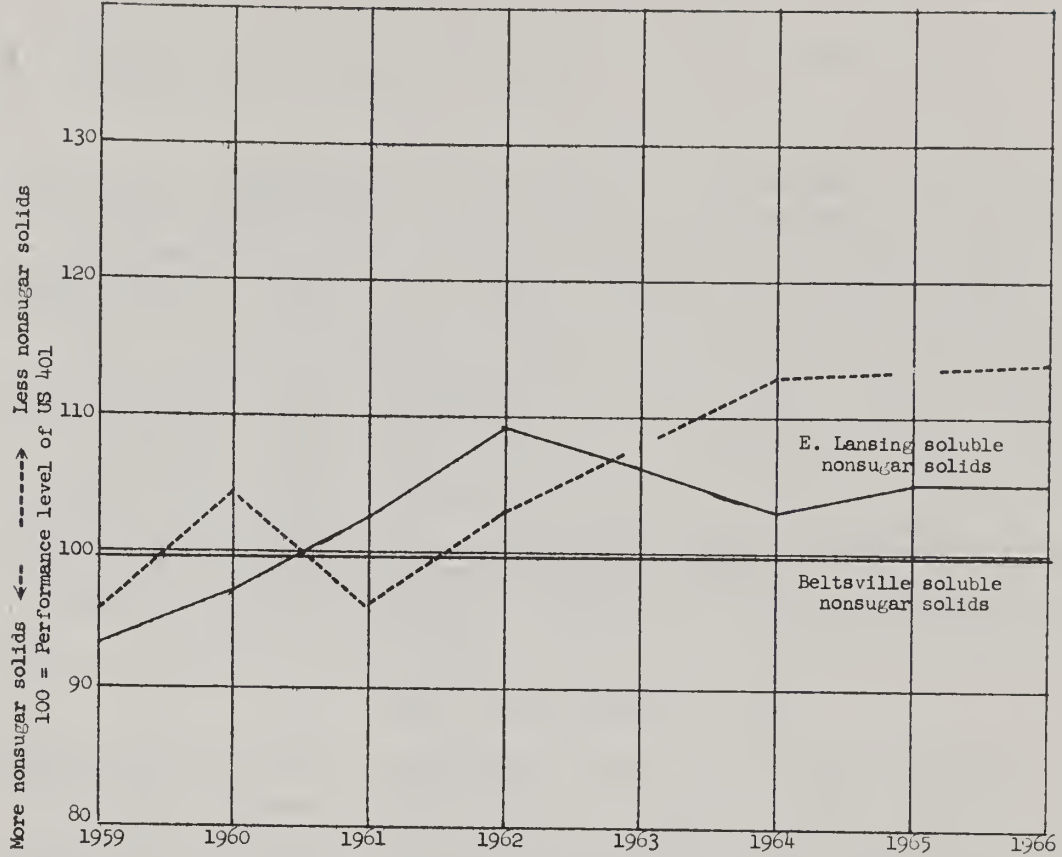
Graph 5. Sugar percentage performance of multigerm breeding lines.



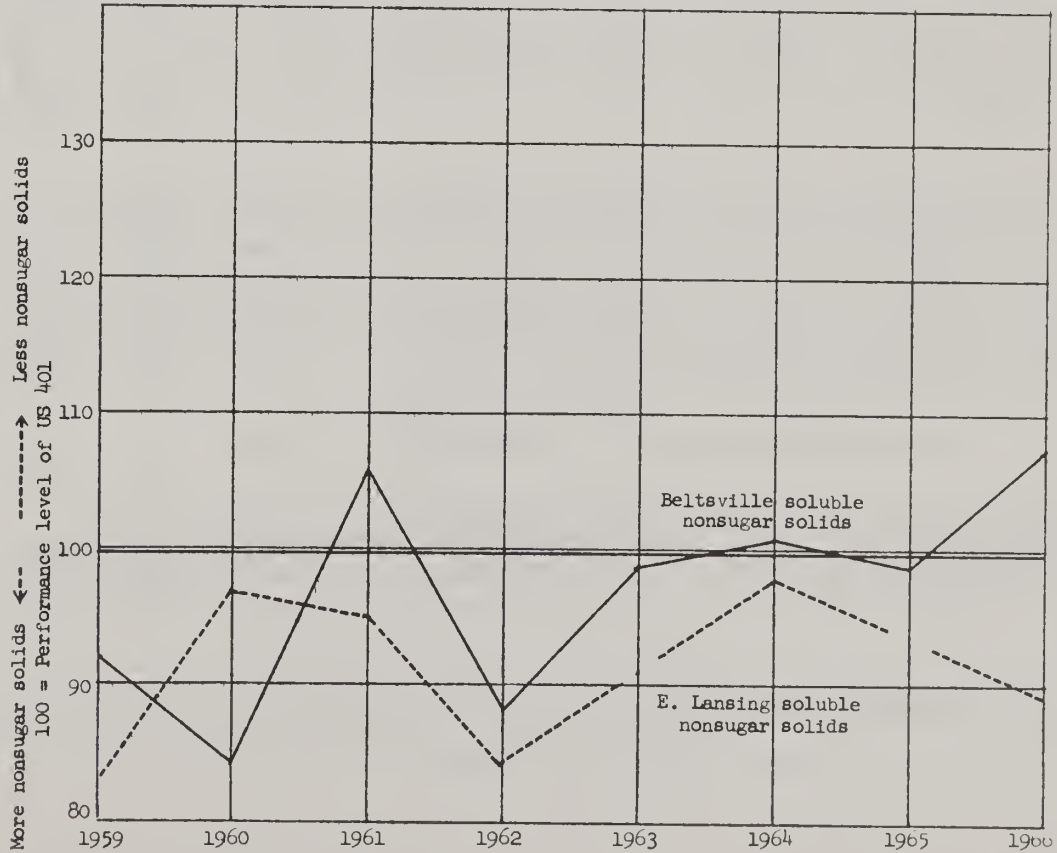
Graph 6. Sugar percentage performance of monogerm breeding lines.



Graph 7. Percentage soluble nonsugar solids performance of multigerm breeding lines.



Graph 8. Percentage soluble nonsugar solids performance of monogerm breeding lines.



Soluble nonsugar solids in the multigerm breeding lines in 1966 were less than that of US 401 as it has been since 1961. The data since 1961 indicate that if any progress has been made in reducing these soluble nonsugar solids in the multigerms, it has been rather slight. On the other hand, if selections were not constantly being made to eliminate plants having high percentage of soluble nonsugar solids, the amount of these substances in the breeding material would undoubtedly increase. Selections to decrease the amount of soluble nonsugar solids in monogerm lines appear to have been successful if one looks only at the data from the Beltsville nursery. Data from the East Lansing nursery indicate year to year fluctuation in these soluble solids but no trend of improvement. Improvement of this characteristic is only by small increments. More extensive and precise tests would be necessary to accurately determine the rate of change in content of soluble nonsugar solids. (See Graphs 7 and 8).

New Monogerm Type-0 Lines

In the spring of 1966, test crosses of selected pollen-fertile monogerm plants indicated that many did not restore pollen fertility in the F₁ progeny and are probably type-0. When available, hybrid seed of the male-sterile parent and selfed seed of the presumptive type-0 monogerm plant were planted in the greenhouse. On May 15, the progenies were transplanted into the leaf spot nursery. Although the leaf spot was not severe, the epidemic was adequate to obtain some information concerning the tolerance of these lines. Leaf spot evaluations are presented in Table 1. Leaf spot evaluations were made on a basis of 0 to 10, 0 being no spots on the leaves and 10 being complete blighting of the foliage.

The selfed progeny of the new monogerm type-0 plants were generally more resistant to leaf spot than their hybrid male-sterile progeny because the tester plants came from lines relatively low in resistance. The resistance of the male-sterile component of the new lines will undoubtedly increase with backcrossing to their more resistant pollen-fertile companions. The combining ability of most of these male-sterile lines will be tested in nursery plots in 1967.

Experimental Hybrids in the Beltsville Nursery

One hundred and nine experimental hybrids were tested for leaf spot resistance in the Beltsville nursery in 1966. These hybrids occurred in 4 different experiments. Their performances are not comparable except through certain check varieties that were included in all the tests.

- (1) The experiments were planted on May 5 in triple-lattice design.
- (2) The plots were single-row, 20 feet long.

Table 1. Leaf spot evaluation of selfed and hybrid progeny of new monogerm type-0 plants.

Seed Number	Leaf Spot Reading*	Seed Number	Leaf Spot Reading*
SP 6322-0**	1	SP 65554. PF	2
US 401 **	3		
		SP 65555. PF	1
SP 65500. PF	2	SP 65555-1 MS	3
SP 65500-1 MS	2		
		SP 65559. PF	2
SP 65502. PF	1	SP 65559-1 MS	3
SP 65503. PF	2	SP 65567. PF	3
SP 65503-1 MS	2	SP 65567-1 MS	3
SP 65505. PF	1	SP 65576. PF	3
SP 65505-1 MS	1	SP 65576-1 MS	3
SP 65506. PF	1	SP 65584. PF	3
SP 65506-1 MS	2	SP 65584-1 MS	4
SP 65509. PF	2	SP 65599. PF	2
SP 65509-1 MS	2	SP 65599-1 MS	3
SP 65515. PF	1	SP 65604. PF	3
SP 65515-1 MS	2		
		SP 65621. PF	2
SP 65519. PF	1	SP 65621-1 MS	3
SP 65519-1 MS	2		
		SP 653308. PF	2
SP 65529. PF	1		
SP 65529-1 MS	2	SP 653332. PF	4
		SP 653332-1 MS	4
SP 65530. PF	3		
SP 65530-1 MS	4	SP 653334. PF	3
		SP 653334-1 MS	3
SP 65547. PF	2		
SP 65547-1 MS	2	SP 653351. PF	3
		SP 653351-1 MS	3
SP 65550. PF	1		
SP 65550-1 MS	3	SP 653365. PF	3
		SP 653365-1 MS	2
SP 65552. PF	2		
SP 65552-1 MS	2		

*0 = No spots on leaves. 10 = Complete defoliation caused by leaf spot. **Standard multigerm check variety.

- (3) The first 10 plants of each row were taken for laboratory analyses.
- (4) All the beets in the row were weighed.
- (5) Harvest was October 20.
- (6) The root yield, % sucrose and gross sugar yields are given as percent of the performance of the commercial hybrid, SL(129 x 133) X SP 5822-0.

In experiment 1 (Table 2), 8 of 10 hybrids produced in the greenhouse in the winter of 1965-66 were better than SP 6322-0 in root yield. This is probably attributable to improved MS lines. In experiment 2 (Table 3), the hybrids having MS parents of East Lansing and Beltsville origin were better in root yield than hybrids with MS parents of western origin. This is not related to the leaf spot resistance of the hybrids. In experiments 3 and 4 (Table 4), the hybrids having SP 5822-0 as a pollinator were superior to hybrids having SP 59B18-0 as a pollinator. This is at least partially due to the better leaf spot resistance of SP 5822-0. The hybrids in experiment 3 and 4 having FC 502/2 as component of the MS parent were among the best hybrids in the test. Again, this is at least partially attributable to the superior leaf spot resistance of FC 502/2.

Increasing the Severity of Leaf Spot in Nursery Trials

The increased resistance of breeding lines to *Cercospora* leaf spot makes it difficult if not impossible to determine which of the more resistant lines are best. If the severity of the leaf spot epidemic could be increased, it might be easier to distinguish the most resistant lines. An experiment was run to determine if alternate rows planted with a vigorous but somewhat susceptible hybrid would increase the leaf spot in adjacent rows containing the breeding lines. The breeding lines were planted in rows 2 feet apart. In one replication in each of 2 experiments, the susceptible hybrid was planted between and on the outside of the 2 ft. rows creating a 1 ft. row spacing in each of these replications. There was significantly more leaf spot on the breeding lines in the replications with the interplanted rows of susceptible hybrid (Tables 5 and 6). However, the increased severity of leaf spot might be attributable to one or both of 2 factors: (1) the increase of inoculum available due to the presence of the susceptible hybrid; and (2) improved environmental conditions for the development of the disease because of the higher plant population per acre. This experiment will be repeated in 1967 with all row widths at 2 ft.

Table 2. Harvest data for experiment 1 in 1966 Beltsville, Md. Leaf Spot Nursery.

(3 replications: plots 1-row, 20 feet long)

Variety		Acre Yield		% Sucrose	Raw Juice Apparent Leaf Spot Harvest		
		Gross Sugar	Tons Beets		Purity	Rating	Stand Count
		% of check	% of check	% of check	Percent	Numerical	Number
SP 6468-1	X SP 6322-0	151	159	95	82.03	3.00	85
SP 64218-01	X "	150	154	97	79.27	3.00	93
SP 643448-2	X "	149	162	92	81.27	3.33	93
SP 64217-01	X "	149	154	97	79.34	3.33	100
SP 631154H01	X SP 62326-3	147	152	97	81.25	3.67	83
SP 64502-01	X SP 6428-0	145	137	106	80.87	3.00	85
SP 6423-01	X "	142	150	94	79.84	4.67	88
SP 6426-01	X "	142	145	98	82.39	4.00	93
SP 64209-03	X SP 6322-0	140	144	98	79.36	3.67	95
SP 643301-1	X "	139	156	89	80.33	4.00	93
SP 631154H01	X SP 62320-3A	139	153	91	79.70	3.67	93
SP 6423-01	X SP 5822-0 4n	133	145	92	80.14	4.00	90
SP 6322-0 Multigerm		131	140	94	80.42	3.00	92
SP 643465-1	X SP 6322-0	130	136	96	80.65	3.33	100
SP 6442-1	X "	130	155	84	79.28	4.00	90
SP 6423-01	X SP 62326-3	129	138	93	80.29	4.00	85
SP 65406-01	X SP 6322-0	128	142	90	79.67	4.00	87
CT 5 x SL 129	X SP 6428-0	128	135	95	79.88	5.00	103
SL 126	X "	128	135	94	81.12	5.00	88
SP 65363-01 mM hybrid		128	136	94	81.55	4.00	92
SL 129 x SL 133	X SP 6428-0	127	128	99	81.57	4.33	93
SL 129	X "	124	123	101	80.64	5.00	88
SP 631154H01	X SP 5822-0 4n	123	125	97	82.53	4.00	92
US H20		122	126	96	79.21	4.33	92
SL 126 x SP 6121-0	X SP 6428-0	122	135	90	79.01	4.67	83
SL 126 x SL 129	X "	120	129	93	79.79	5.00	98
3061 MS	X "	118	124	96	81.20	4.67	92
SL 129 x SP 6121-0	X "	117	123	95	81.53	4.33	90
SP 6423-01	X SP 62320-3A	117	121	96	81.53	4.33	95
SL 133	X SP 6428-0	114	112	102	82.71	4.33	83
SP 65363-02 mm hybrid		113	126	90	80.30	5.00	88
CT 5 x SP 6121-0	X SP 6428-0	110	121	91	79.94	5.00	90
SP 6423-01	X SP 6322-0	106	118	90	77.90	5.00	92
SP 65499-01 mm hybrid		101	110	92	80.35	5.00	87
SL 129 x SL 133	X SP 5822-0	100	100	100	81.73	4.00	88
		(4047#)	(14.88T/A)	(13.6%)			
US 401 Multigerm		99	112	88	80.01	4.67	85
General MEAN of all varieties		135	135	95	80.55	4.06	91
S.E. of MEAN		2.00	2.05	.56	.20	.08	.83
L.S.D. (.05)		32	30	10	NS	1.0	NS
Coefficient of Variation (%)		11.50	10.80	5.23	2.50	12.40	7.5

Table 3(A): Gross Sugar, % of check, (Experiment 2:

Leaf Spot Test, Beltsville, Maryland, 1966

Table 3(C) Percent Sucrose, % of check, (Experiment 2)

Performance of	Female line	Pollinators		Aver.	Other Materials			
		SP 6429-0	SP 6428-01	SP 6427-0	for	65B2X	SL(129 X : 6241X:	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Pol., etc.		106	98	107		106	100	86
							(13.03%)	100
Hybrids	EL 35 cl x EL 32	102	95	95	97 bc			
"	SP 64218-1	99	94	100	98 bc			
"	SP 64408-1	93	92	92	92 c			
"	SL 129 x FC 503	103	102	104	103 ab			
"	SL 133 x EL 34	98	102	105	102 ab			
"	SL 129 x EL 33	97	104	93	98 bc			
"	SL 129 x SP 6121-0	101	97	97	98 bc			
"	SL 133 x FC 503	106	103	108	106 a			
"	CT 5 x SP 6121-0	95	104	94	98 bc			
Average for pollinators		99	99	99				
LSD (.05) for individual varieties				10.4				
LSD (.05) for pollinator averages				NS				

Leaf Spot Test, Beltsville, Maryland, 1966

Table 3(D) Average Leaf Spot Rating, Numerical, (Experiment 2)

Performance of	Female line	Pollinators			Aver. for	Other Materials			
		SP 6429-0	SP 6428-01	SP 6427-0		65E2X	SL(129 X	63B.X	SP 5822-0
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Pol., etc.		2.33	2.67	3.33		3.33	4.00	5.00	2.33
Hybrids	EL 35 cl x EV 32								
"	SP 64218-1	3.00	4.67	4.00	3.89 bc				
"	SP 64408-1	3.00	3.33	3.33	3.22 a				
"	SL 129 x FC 503	3.33	3.67	3.67	3.56 abc				
"	SL 133 x EL 34	3.67	4.00	4.00	3.89 bc				
"	SL 129 x EL 33	3.67	3.67	4.23	3.89 bc				
"	SL 129 x SP 6121-0	3.33	3.33	4.33	3.67 abc				
"	SL 129 x FC 503	4.00	4.00	4.33	4.11 c				
"	SL 133 x FC 503	3.00	3.33	4.00	3.44 ab				
"	CT 5 x SP 6121-0	3.67	3.67	3.67	3.67 abc				
Average for pollinators		3.41	3.74	3.96					
LSD (.05) for individual varieties			1.19						
LSD (.05) for pollinator averages			.32						

Leaf Spot Test, Beltsville, Maryland, 1966

Table 4(d) Root Yield, % of check, (Experiment 3 & 4)

Performance :		:		:		:		:		Other Material	
of :		:		:		:		:		:	
:		:		:		:		:		:	
(1)		(2)		(3)		(4)		(5)		(6)	
Pol., etc.				116		129		105		114	
Hybrids	FC 502/2 x SP 581181s ₁			142	116						
"	FC 504			157	123						
"	FC 502/2			145	96						
"	SP 602105s ₁ x FC 502/2			129	114						
"	SP 602116s ₁ x FC 502/2			118	129						
"	SP 612046s ₁ cl			121	117						
"	FC 502/2 x FC 505			126	121						
"	SP 602105s ₁ x FC 505			130	106						
"	FC 502 x FC 503			128	106						
"	SP 612083s ₁			121	106						
"	SP 602105s ₁ x SP 581181s ₁			107	121						
"	SP 592087s ₁			126	108						
"	FC 601			128	101						
"	FC 505 x SP 581181s ₁			118	109						
"	SP 581222s ₁ x SP 581181s ₁			126	89						
"	SP 612083s ₁			115	101						
"	SP 602105s ₁ x SP 602116s ₁			117	105						
"	SP 581181s ₁			114	96						
"	SP 581222s ₁ x SP 602116s ₁			126	83						
"	SP 581222s ₁ x FC 505			103	111						
"	SP 612054s ₁ cl			107	120						
"	SP 612068s ₁ cl			117	96						
"	SP 602116s ₁ x SP 581181s ₁			107	90						
"	FC 505 x SP 602116s ₁			124	85						
Averages for pollinators				123	106						
LSD (.05) for individual varieties						18					
LSD (.01) for pollinator averages						14					
LSD (.05) for female lines						NS					

Leaf Spot Test, Beltsville, Maryland, 1966

Table 4(C) Percent Sucrose, % of check, (Experiment 3 & 4)

Performance of	Female line	Pollinators		Aver.	Other Material				
		SP 5822-0	SP 5818-0	for	612033s	FC 505			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	
Pol., etc.		92			92	98	97	100	(13.50)
Hybrids	FC 502/2 x SP 581181s ₁	102	101	102 abc					
"	FC 504	95	94	95 bc					
"	FC 502/2	111	104	108 a					
"	SP 602105s ₁ x FC 502/2	101	104	103 abc					
"	SP 602116s ₁ x FC 502/2	102	94	98 abc					
"	SP 612046s ₁ cl	105	100	103 abc					
"	FC 502/2 x FC 505	101	99	100 abc					
"	SP 602105s ₁ x FC 505	102	101	102 abc					
"	FC 502 x FC 503	103	100	102 abc					
"	SP 612083s ₁	109	100	105 ab					
"	SP 602105s ₁ x SP 581181s ₁	107	97	102 abc					
"	SP 592087s ₁	100	97	99 abc					
"	FC 601	100	100	100 abc					
"	FC 505 x SP 581181s ₁	100	92	96 bc					
"	SP 581222s ₁ x SP 581181s ₁	102	94	98 abc					
"	SP 612083s ₁	100	100	100 abc					
"	SP 602105s ₁ x SP 602116s ₁	95	95	95 bc					
"	SP 581181s ₁	101	101	101 abc					
"	SP 581222s ₁ x SP 602116s ₁	101	94	98 abc					
"	SP 581222s ₁ x FC 505	100	93	97 abc					
"	SP 612054s ₁ cl	92	90	91 c					
"	SP 612068s ₁ cl	96	95	96 bc					
"	SP 602116s ₁ x SP 581181s ₁	100	96	98 abc					
"	FC 505 x SP 602116s ₁	'89	94	92 c					
Averages for pollinators		101	97						
LSD (.05) for individual varieties			9						
LSD (.05) for pollinator averages			4						

Leaf Spot Test, Beltsville, Maryland 1966

Table 4(D) Pol. Ex. Purity, percent, (Experiment 3 & 4)

Performance of	Female line	Pollinators		Aver. for	Other Materials		
		: SP 5822-0	: SP 59B18-0		: 612033s ₁	: X	: X
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Pol., etc.		81.10			80.97	81.91	80.16 81.17
Hybrids	FC 502/2 x SP 581181s ₁	80.57	80.80	80.69 abcd			
"	FC 504	80.46	80.43	80.45 abcd			
"	FC 502/2	81.66	81.97	81.82 a			
"	SP 602105s ₁ x FC 502/2	81.41	81.42	81.42 abc			
"	SP 602116s ₁ x FC 502/2	80.73	81.21	80.97 abcd			
"	SP 612046s ₁ cl	79.70	80.12	79.91 abcde			
"	FC 502/2 x ¹ FC 505	79.75	78.82	79.29 de			
"	SP 602105s ₁ x FC 505	81.06	79.35	80.21 abcd			
"	FC 502 x FC 503	80.17	79.66	79.92 abcde			
"	SP 612083s ₁	81.51	79.56	80.54 abcd			
"	SP 602105s ₁ x SP 581181s ₁	81.35	79.23	80.29 abcde			
"	SP 592087s ₁	83.03	79.76	81.40 abc			
"	FC 601	80.01	79.55	79.68 bcde			
"	FC 505 x SP 581181s ₁	82.22	79.96	81.09 abcd			
"	SP 581222s ₁ x SP 581181s ₁	80.74	78.69	79.72 bcde			
"	SP 612083s ₁	82.42	81.18	81.80 a			
"	SP 602105s ₁ x SP 602116s ₁	80.49	81.30	80.90 abcd			
"	SP 581181s ₁	81.58	80.59	81.09 abcd			
"	SP 581222s ₁ x SP 602116s ₁	82.41	80.91	81.66 ab			
"	SP 581222s ₁ x FC 505	81.17	77.89	79.53 cde			
"	SP 612054s ₁ cl	78.30	78.35	78.33 e			
"	SP 612068s ₁ cl	81.33	80.55	80.94 abcd			
"	SP 602116s ₁ x SP 581181s ₁	80.38	79.39	79.89 abcde			
"	FC 505 x SP 602116s ₁	78.36	78.58	78.47 e			
Average for pollinators		80.87	79.96				
LSD (.05) for individual varieties			NS				
LSD (.01) for pollinator averages			.68				

Leaf Spot Test, Beltsville, Maryland, 1966

Table 4(E) Leaf Spot Rating, Numerical, (Experiment 3 & 4)

Performance of	Female line	Pollinators	Aver.	Other Material		
				FC 505	FC 505	FC 505
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Pol., etc.		4.33			4.00	3.67
Hybrids	FC 502/2 x SP 581181s ₁	3.00	3.00	3.00 abc		
"	FC 504	2.67	3.00	2.84 ab		
"	FC 502/2	2.00	3.00	2.50 a		
"	SP 602105s ₁ x FC 502/2	3.00	2.67	2.84 ab		
"	SP 602116s ₁ x FC 502/2	3.00	3.33	3.17 abcd		
"	SP 612046s ₁ cl	2.33	3.00	2.66 a		
"	FC 502/2 x FC 505	3.00	3.33	3.17 abcd		
"	SP 602105s ₁ x FC 505	4.00	4.00	4.00 bcde		
"	FC 502 x FC 503	3.33	3.67	3.50 abcde		
"	SP 612083s ₁	2.67	3.00	2.84 ab		
"	SP 602105s ₁ x SP 581181s ₁	4.33	4.67	4.50 e		
"	SP 592087s ₁	3.00	3.33	3.17 abcd		
"	FC 601	3.67	3.33	3.50 abcde		
"	FC 505 x SP 581181s ₁	3.67	4.67	4.17 cde		
"	SP 581222s ₁ x SP 581181s ₁	4.00	4.67	4.33 de		
"	SP 612083s ₁	4.00	4.33	4.17 cde		
"	SP 602105s ₁ x SP 602116s ₁	3.33	5.00	4.17 cde		
"	SP 581181s ₁	4.33	4.00	4.17 cde		
"	SP 581222s ₁ x SP 602116s ₁	3.67	4.67	4.17 cde		
"	SP 581222s ₁ x FC 505	4.00	5.00	4.50 e		
"	SP 612054s ₁ cl	4.00	4.33	4.17 cde		
"	SP 612068s ₁ cl	3.67	4.33	4.00 bcde		
"	SP 602116s ₁ x SP 581181s ₁	4.33	5.00	4.67 e		
"	FC 505 x SP 602116s ₁	3.67	4.33	4.00 bcde		
Averages for pollinators		3.44	3.90			
LSD (.05) for individual varieties			1.02			
LSD (.01) for pollinator averages			.33			

Table 5. Leaf spot ratings of monogerm breeding lines with and without interplanted rows of susceptible hybrid.

Replication	Totaled leaf spot ratings of 36 lines
First	111
Second (with susceptible hybrid interplanted)	143
Third	106
General MEAN of replications	120
S. E. of MEAN	3.03
Significant Difference (100:1)	10.80
Coefficient of Variation (%)	13.58

Table 6. Leaf spot ratings of multigerm breeding lines with and without interplanted rows of susceptible hybrid.

Replication	Totaled leaf spot ratings of 36 lines
First	118
Second	108
Third (with susceptible hybrid interplanted)	135
General MEAN of replications	120.3
S. E. of MEAN	2.77
Significant Difference (100:1)	11.88
Coefficient of Variation (%)	15.02

